QUANTIFICATION PROTOCOL FOR WETLANDS RESTORATION

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Specified Gas Emitters Regulation

Government of Alberta

Alberta

Disclaimer:

The information provided in this document is intended as guidance only and is subject to periodic revisions. This document is not a substitute for the law. Please consult the *Specified Gas Emitters Regulation* and applicable legislation for all purposes of interpreting and applying the law. In the event that there is a discrepancy between this document and the *Specified Gas Emitters Regulation* or other legislation, the *Specified Gas Emitters Regulation* and other legislation prevail.

All Quantification Protocols approved under the *Specified Gas Emitters Regulation* are subject to periodic review as deemed necessary by the Department, and will be re-examined at a minimum of every 5 years from the original publication date to ensure methodologies and science continue to reflect best-available knowledge and best practices. Any updates to protocols occurring as a result of the 5-year and/or other reviews that are not due to legal requirements will apply at the end of the first credit duration period for applicable project extensions and for all new projects coming forward.

Where a project condition differs from approved government methodologies, or the project developer is unclear on protocol interpretation relative to their specific project, the project developer must contact Alberta Environment to discuss an appropriate interpretation and receive approval for any methodology changes prior to undertaking the project.

Any comments, questions, or suggestions regarding the content of this document may be directed to:

Alberta Environment
Climate Change Secretariat
12th Floor, 10025 – 106 Street
Edmonton, Alberta, T5J 1G4
E-mail: **AENV.GHG@gov.ab.ca**

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[1] Alberta Environment is developing guidance for third party verification.

1.0 Offset Project Description

Projects that are implemented according to this protocol generate carbon offsets by restoring freshwater mineral soil wetlands on private lands in the Prairie Pothole Region of Alberta. Once predominant in the landscapes of the Prairie Pothole Region, the vast majority of seasonal, semi-permanent and permanent wetlands have been degraded or drained to accommodate expanded agricultural activity. As a result of wetland drainage, soil organic carbon sequestered through wetland function has been lost to the atmosphere. Restoration of wetlands re-establishes the processes to achieve net sequestration of carbon.

Restoration of freshwater mineral soil wetlands is carried out by a Wetland Restoration Agency through installation of 'earth plugs' to reverse drainage. Administration of restoration activity under long-term land use agreements assures the restored wetland achieves real, permanent, and verifiable net sequestration of carbon. Further, restoring wetlands and managing the associated upland provides co-benefits in the landscape, including abated nutrient losses, increased biodiversity, and regulated flow and quality of water.

This quantification protocol is written for environmental professionals, Wetland Restoration Agencies, project developers, and aggregators. The project developer/aggregator will work with the Wetland Restoration Agency and environmental professional to compile the project(s) in accordance with this protocol and the criteria of the Alberta offset system.

1.1 Protocol Scope

The scope of this protocol is limited to the net removals of GHGs achieved by restoration of wetlands by reversal of drainage. After accounting for methane and nitrous oxide emissions, restoration of wetlands results in a net sequestration of carbon relative to the baseline condition of a drained wetland (Badiou *et al.* Submitted).

The consensus of science requires that, in addition to restoration of the wetland, ongoing management of the basin, margin and associated upland is needed to ensure the GHG mitigation potential of the restored wetland is achieved (Houlahan and Findlay 2004, Voldseth *et al.* 2007, Barzen 2008). In alignment with this consensus, Badiou *et al.* (Submitted) included the net rate of soil organic carbon accumulation in the margin to calculate the net sequestration coefficient for the restored wetland. Numerous studies support the conclusion that upland land use influences wetland GHG dynamics. For example, the management of the upland will influence the hydrology of the catchment area of the wetland (Voldseth *et al.* 2007, Euliss *et al.* 2008, Gleason *et al.* 2008, Pennock *et al.* 2010). And, if excess soluble nitrogen accumulates in the upland soil and leaches or runs-off into the wetland, the potential exists for emissions of N_2O from the wetland in sufficient magnitude to make the restored wetland a net source of emission reductions

(Merbach *et al.* 2002, Gleason *et al.* 2005). The Wetlands Restoration Protocol thus requires that uplands associated with restored wetlands must be managed to support wetland function.

Science thus supports the use of the area of wetland basin and margin for the calculation of net carbon sequestered through wetland restoration. But, operationally, wetland restoration activity is planned and documented according to the fully supply level, denoting the area within the elevation line of the top of the earth plug. The full supply level boundary, however, does not always encompass the complete margin area. Therefore, in the Wetlands Restoration Protocol, the margin area outside the full supply level must be managed as prescribed by the Protocol, but will not generate offsets under the Protocol. Further, offsets potentially generated by emission reduction activities on the uplands are not included in the calculations of the Wetlands Restoration Protocol. To enable rigor of documentation and to ensure conservativeness in quantification, the Wetland Restoration Protocol defines the area of restored wetland used to generate offsets as the area within the full supply level contour line.

Other emission reduction activities, where quantification protocols exist in the Alberta Offset System, can be used in conjunction with this protocol. For example, Agricultural Nitrous Oxide Emissions Reductions Protocol or the Tillage Quantification Protocol can be added or "stacked" to create greater opportunities for land managers. Other protocols, such as Conversion to Perennial Forages, may be 'stacked' if they achieve approval in the Alberta Offset System.

Emission Reduction Activity

Freshwater mineral soil wetlands of the Prairie Pothole Region, once numbered at about 20 million, are one of the most threatened ecosystems in North America as a result of drainage associated with expansion of agricultural activity (Dahl 2006, Euliss *et al.* 2006, Watmough and Schmoll 2007, Bartzen 2008). Drainage of these wetlands decreases CH_4 in the basin, slows processes of carbon deposition (i.e. plant productivity), increases rate of CO_2 emission from decomposition, and may increase N_2O emission. Reversal of drainage enhances primary productivity, slows decomposition, increases CH_4, and may decrease N_2O from the basin. In net, after accounting for the CH_4 and N_2O [2] emissions from the basin, restoration of the freshwater mineral soil wetlands in the Prairie Pothole Region of Alberta achieves net sequestration of 3.25 Mg CO_2e ha^{-1} y^{-1} (Badiou *et al.* Submitted).

This protocol manages the sequestration process by restoring wetland function through:

[2] Although N_2O emissions potentially are decreased in restored wetland basins relative to drained wetland basins, this reduction potential is not included in the offset calculation of the Wetlands Restoration Protocol. This is one of the elements of conservativeness incorporated in the net sequestration coefficient used in the Protocol.

- Removal of drainage structure from a previously-existing Class 3, 4 , or 5 wetland (no excavation of the pre-existing basin is allowed, so restoring a wetland as a dugout is not an eligible activity)[3];
- Protection of the area of the restored wetland within the fully supply level, and;
- Prescription for management of the margin area outside the full supply level boundary, and of the upland associated with the restored wetland.

The Wetlands Restoration Protocol is designed to harmonize with legislation; namely, the Alberta Water Act, which provides regulation concerning wetlands. The Wetlands Restoration Protocol requires documentation to assure the restoration activity carried out to generate offsets is not required by the Water Act. And, once wetlands are restored under the Wetlands Restoration Protocol, these are required to be reported to Alberta Environment (Water Resources) for protection according to the restrictions in the Water Act.

Eligible Project Conditions

The project condition includes the wetland as well as the margin outside the full supply level boundary and the associated upland. To be consistent with the Tillage Management System Protocol, the registration period for projects under the Wetlands Restoration Protocol will be 20 years.

The Wetlands Restoration Protocol prescribes management of the margin outside the full supply level boundary and of the associated upland. The management of the margin area outside the full supply level boundary and of the associated upland will involve maintenance of permanent cover or of cropland management according to the prescribed practices of GHG reduction quantification protocols approved in the Alberta Offset System. But, the reductions and/or removals potentially generated by this activity in the margin or upland are not included in the calculation of the Wetlands Restoration Protocol. These potential offsets would need to be generated by implementing other protocols approved under the Alberta Offset System.

Net carbon sequestration is quantified as 3.25 Mg CO_2e ha^{-1} y^{-1} of wetland restored; namely, the area within the boundary of the full supply level.

To use this protocol, Project Developers must:

- Provide documentation that a Wetlands Restoration Agency, which likely will employ Qualified Wetland Aquatic Environment Specialists, will carry out all restoration activity and monitoring;

[3] The net sequestration expected after restoration is the result of increased carbon deposition as plant biomass and decreased carbon decomposition as a result of submerged conditions. In a dugout, plant growth will be minimal and so little plant biomass will be deposited. Thus, the conditions in a dugout are not aligned with the conditions under which the net coefficient was derived.

> Note! It is the responsibility of the Project Developer to ensure the Protocol requirements are met. However, the content of the agreement between Project Developer and Wetlands Restoration Agency may vary. That is, in some instances the Project Developer and Wetlands Restoration Agency may be the same entity. In some cases, the agreement may be for a term, and more than one Wetlands Restoration Agency could be engaged throughout the registration period. Regardless of the agreement details, the restoration and monitoring must be carried out by a Wetlands Restoration Agency.

- Provide documentation concerning the Purchase Agreement (if purchased by conservation organization for wetland restoration), Conservation Easement, or 30-year Wetland Restoration Agreement used to protect the restored wetland;
- Provide documentation of ownership of offsets;
- Provide evidence that a wetland proposed for restoration represents a previously drained wetland of Class 3, 4, or 5;
- Develop and implement a plan for the restoration of the wetland;

> Note! A license to build an earth plug is not included as a project requirement, because obtaining such approval is part of the duties of a Wetland Restoration Agency in the restoration process.

- Develop and implement a plan following restoration for the management of the wetland, the margin outside the full supply level, and the associated upland;
- Implement procedures and controls for ongoing monitoring of the restored wetland, the margin outside the full supply level, and the associated upland; and
- Calculate project emission reductions on a per ha of restored wetland;

The project condition requires reversal of wetland drainage, management of the restored wetland and associated upland, and wetland delineation and monitoring procedures.

Management of the wetland according to the requirements of the Wetlands Restoration Protocol involves termination and prevention of burning, clearing, and cultivating of the wetland margin.

In projects administered under Conservation Easements, which prescribe 'no break, no drain' management, the land use agreement frames the management of the upland associated with the wetland.

For projects under 30-Year Wetland Restoration Agreements, which leave upland management to the discretion of the land owner, Project Developers must provide the plan to ensure management in the margin outside of the fully supply level and of the associated upland supports wetland function. This plan shall require landowners to maintain perennial cover by establishing grassland or forest land. Alternatively, if the

land owner grows cultivated crops, the plan shall require landowner to fulfill the requirements of the 4R nitrogen management plan prescribed in the Agricultural Nitrous Oxide Emissions Reductions Protocol, and to use zero till as prescribed in the Tillage Quantification Protocol.

Justification for the Baseline

This protocol uses a static historic benchmark baseline approach. This approach requires evidence that a freshwater mineral soil wetland (Stewart and Kantrud Class 3, 4, or 5) existed on the site in the past, was drained, and now is proposed for restoration through reversal of the drainage structure.

Photogrammetric survey data, and on-site field confirmations where necessary (as prescribed in Procedures Manual), will provide evidence of the location and size of the previously drained wetland. The implementation of the plans for restoration of the wetland and for management of the wetland and associated upland will result in a land use change which will achieve net carbon sequestration.

The wetland restoration project(s) achieves changed and sustained land use change through:

1. Providing plans for restoration of the wetland and for management of the margin and the associated upland;
2. Providing long-term agreements with land owners;
3. Reporting of restored wetlands to Alberta Environment for protection under the restrictions of the Alberta Water Act; and
4. Contributing data from restored wetlands to the Alberta Environment inventory.

The Restoration Agency identifies the baseline management practice of the Project Developer, and administers management and monitoring of the project condition.

The comparable metric for calculating emission reductions between baseline and project conditions is achieved by expressing emissions on a basis of per hectare of wetland restored. This ensures that emissions are normalized to a common base unit, thereby allowing quantification of real emissions reductions resulting from the project condition.

The net carbon sequestration from wetlands restoration is quantified with a coefficient derived from extensive research in the Prairie Pothole Region. Studies have consistently concluded freshwater mineral soil wetlands are carbon sinks (Gleason *et al.* 2005, Bedard-Haughn *et al.* 2006; Euliss *et al.* 2006). Recent studies have quantified the greenhouse gas flux from these systems (Phipps 2006, Hartwig 2008, Phillips and Beeri 2008, Gleason *et al.* 2009; Pennock *et al.* 2010). Badiou *et al.* (Submitted) integrated soil organic carbon and GHG flux data from 62 wetlands from 22 sites in western Canada (22 wetlands never cultivated, 14 wetlands restored for less than 5 years, 26 wetlands

restored for more than 5 years) to derive a net sequestration coefficient. The coefficient is thus derived using data from Alberta, but this data is consistent with other data obtained for the Prairie Pothole Region.

All three major agricultural greenhouse gases are integrated in the net sequestration coefficient used in the Wetlands Restoration Protocol (Table 1).

Table 1: Relevant Greenhouse Gases Applicable for *Wetlands Restoration*

Specified Gas	Formula	100-year GWP	Applicable to Project
Carbon Dioxide	CO_2	1	Y
Methane	CH_4	21	Y
Nitrous Oxide	N_2O	310	Y
Sulphur Hexafluoride	SF_6	23,900	N
Perfluorocarbons*	PFCs	Variable	N
Hydrofluorocarbons*	HFCs	Variable	N

* A complete list of perfluorocarbons and hydrofluorocarbons regulated under the *Specified Gas Emitters Regulation* is available in Technical Guidance for Offset Project Developers.

1.2 Protocol Applicability

To apply this protocol, the Project Developer must prove the following requirements:

1. A Wetland Restoration Agency is engaged to carry out the requirements of the protocol;
2. These restoration activity is administered under a Purchase Agreement by a conservation organization, Conservation Easement, or a 30-Year Wetland Restoration Agreement;

> Note! If land purchased for restoration by a conservation organization is submitted for participation in the Protocol, a conservation easement must be attached to the land to ensure the wetland is protected if the land is sold. This is consistent with the normal practice of conservation organizations which use revolving land purchases to finance conservation activity.

3. The baseline and project condition are clearly identified;
4. The management of the restored wetland and associated upland is defined and monitored;
5. The quantification of net removals achieved by the project is based on actual measurement and monitoring as required in this protocol; and,

6. The project meets the eligibility criteria stated in section 7.0 of the *Specified Gas Emitters Regulation.* In order to qualify, emissions reductions must:
    - Occur in Alberta;
    - Result from actions not otherwise required by law;
    - Result from restoration activity implemented on or after January 1, 2011, on wetlands drained prior to January 1, 2010;
    - Be real, demonstrable, and quantifiable;
    - Have clearly established ownership including, if applicable, appropriate, documented transfers of ownership from the land owner to land lessee;
    - Be counted once for compliance; and
    - Be implemented according to ministerial guidelines.

Role of the Wetland Restoration Agency:

Project Developers need to engage a Wetlands Restoration Agency to implement projects according this protocol. Participation of the Wetlands Restoration Agency, including sign-off on all activity, is required as part of the mandatory project documentation for protocol projects.

The status of Wetlands Restoration Agency is conferred based on an assessment of an applicant organization by Alberta Environment. The assessment criteria include (but are not limited to): (1) capability to assume long-term liability of conservation and restoration agreements[4]; (2) expertise to carry out delineation and restoration of wetlands; and (3) capability to report restoration activity to Alberta Environment.

The Wetlands Restoration Agency is a key participant in the planning and implementation of restoration in compensation for wetland loss due to land development under the requirements of the Alberta Wetland Loss Compensation activity regulated by Alberta Environment. The Wetlands Restoration Agency: (1) submits compensation proposals; (2) obtains long term (30 year) land interest; (3) completes restoration activity; and, (4) provides Alberta Environment with an annual report on restoration activity, including a listing of wetland restorations (location, size, class, etc.).

The capabilities required for an organization to achieve the status Wetlands Restoration Agency, and the responsibilities a Wetlands Restoration Agency fills in the Alberta

[4] The liability of the Wetlands Restoration Agency with respect to the GHG reduction project is expected to be specified in the agreement with the Project Developer.

Wetland Loss Compensation activity, ensures that a Wetlands Restoration Agency is able to generate real, permanent, and verifiable offsets from wetlands restoration[5].

The Wetlands Restoration Agency is required to:

1. Ensure that the proposed wetland restoration project is not required by regulation (i.e. the restoration is not required as part of an obligation to mitigate for wetland loss associated with development). That is, no offset can be claimed if the restoration is required within the Mitigation requirements under the *Water Act*.;
2. Develop the baseline determination, consisting of the location and extent of the pre-existing and drained wetland, with a depth of at least 0.30 meters, which met the requirements of a naturally occurring and functional Class 3 (seasonal pond), Class 4 (semi-permanent pond), or Class 5 (permanent pond) wetland;
3. Administer long-term land use agreements;
4. Complete topographic surveying of the wetland restoration area, and construct earth plug.
5. Compile the 'as built' survey plan;
6. Report geospatial information concerning the restored wetland to Alberta Environment; and
7. Provide on-going monitoring of the restored wetland;

> Note! The participation of the Wetlands Restoration Agency does not constitute formal validation or verification for the project. Independent, third party verification is required for all Offset Credits being serialized and registered on the Alberta Emissions Offset Registry for use as a compliance option under the *Specified Gas Emitters Regulation.*

The general data requirements for this protocol are shown in Table 2. Additional details are provided in Sections 4 and 5.

[5]At present, there is a shortage of Wetlands Restoration Agencies in Alberta. The revenue potential associated with the Wetlands Restoration Protocol may encourage more organizations to apply for this status.

Table 2: General Overview of Data Requirements to Justify the Baseline and Project Condition for Wetlands Restoration Projects

Data Requirements:	Examples of Records	Why do you need it?
Legal Land location and photogrammetric data of all wetlands and associated uplands.	Legal land description for the registration of the project and ownership or easement or land use agreements between land lessees/land title owners (in tenure situations) and commercial agreements between entitled parties.	Clear title to all of the offset credits (to be verified).
<u>For baseline:</u> • Evidence of existence, class, and extent previous wetland; • Evidence of drainage structure; • Record of the maximum depth of the wetland.	• Aerial or digital maps of wetlands and uplands, showing margin extent, depth of basin(basin proxy measurement method, >0.3m), and location of drainage; • If necessary, lab tests to confirm hydric soils; • Inspection report to record the dimensions of the drain and to determine viability for restoration (address potential for wash out, and for upstream or downstream damages, etc.); • Records of wetlands restored for mandatory compensation or for voluntary offset creation.	To prove that a functional wetland existed, was drained, is viable for restoration, and restoration is not required by regulation.
<u>For project:</u> A plan by the Wetlands Restoration Agency for restoration activity according to the requirements of the Wetlands Restoration Protocol.	• Prior to initial field visit QWAES is required to create an interim restoration plan in a GIS environment; • Signed-off plan for restoration of the wetland and management of the wetland, margin outside boundary of full supply level, and associated upland;	Ensures all procedures will be implemented according to requirements of the Wetlands Restoration Protocol.

	• Copy of Purchase Agreement, Conservation Easement, or 30-Year Wetlands Restoration Agreement.	
<u>For project:</u> • Proof of restoration activity, including documentation of final area of restored wetland; • Record of reporting to Alberta Environment	• Sign-off by landowner to proceed with restoration; • As built survey plan, including: (1) date of survey and construction, project ID number, landowner name; (2) legal land location (and GPS coordinates, if available) of entire quarter section where restored wetland(s) is (are) located; (3) final area, dimension, depth of restored wetland; (4) earth dam location, dimension construction procedure; • Record of submission to provincial repository of geospatial data concerning restored wetland, and other wetlands on lands controlled by participating landowner.	These records are necessary to ensure that correct land area is applied to reduction co-efficient, earth plug is constructed according to the appropriate procedures, an As built plan has been satisfactorily completed, and project management data is available at verification intervals, and for ongoing assessment of permanence.

1.3 Protocol Flexibility

Flexibility in applying the quantification protocol is provided to Project Developers in the following ways:

1. The Wetlands Restoration Protocol is based on the frame of reference provided by the systems, controls, and procedures of Ducks Unlimited Canada, the primary Wetland Restoration Agency in Alberta. Project Developers proposing to use other procedures shall seek approval from Alberta Environment to use these alternative methods.
2. Restoration of wetlands on private lands is the scope of the Wetlands Restoration Protocol. Project Developers, however, may choose to seek approval to include public lands. Justification would be needed to demonstrate how these new wetlands would meet the requirements of the protocol (such as additional to regulation, administered in a long-term land use agreement, management of the associated upland, etc.).

1.4 Glossary of New Terms

Full Supply Level — Full supply level is an engineering term that describes the flood contour corresponding with maximum operating level of a water control structure. In the context of a restored wetland, full supply level is the contour corresponding to the spill elevation of the ditch plug. Any volume of water added to the restored wetland additional to the full supply level will pass through a spillway (or outlet) around the earth plug shoulders and contribute to the downstream basin.

Qualified Wetland Aquatic Environment Specialist (QWAES) — An expert with detailed knowledge of the aquatic environment, wetland soils, wetland species, hydrology and wetland margin habitat and their management or assessment. Credentials of the QWAES are described in the Guide to the Code of Practice for Pipelines and Telecommunication Lines Crossing a Body of Water (Alberta Environment 2007a). The QWAES is provided as an example of the type of personnel a Wetland Restoration Agency may employ, but this designation is not a requirement of the Protocol.

Stewart and Kantrud (1971) wetland classification system —

- **Class 1 - Ephemeral Wetlands** typically have free surface water for only a short period of time after snowmelt or storm events in early spring. Because of the porous condition of the soils, the rate of water seepage from ephemeral wetlands is very rapid after thawing of the underlying frost seal. They may be periodically covered by standing or slow moving water. Water is retained long enough to establish some wetland or aquatic processes. They are typically dominated by Kentucky bluegrass, goldenrod and other wetland or low prairie species.

- **Class 2 - Temporary Wetlands** are periodically covered by standing or slow moving water. They typically have open water for only a few weeks after snowmelt or several days after heavy storm events. Water seepage is fairly rapid, but surface water usually lingers for a few weeks after spring snowmelt and for several days after heavy rainstorms at other times of the year. Water is retained long enough to establish wetland or aquatic processes. They are dominated by wet meadow vegetation such as fine-stemmed grasses, sedges and associated forbs.
- **Class 3 - Seasonal Ponds and Lakes** are characterized by shallow marsh vegetation, which generally occurs in the deepest zone (usually dry by midsummer). These wetlands are typically dominated by emergent wetland grasses, sedges and rushes.
- **Class 4 - Semi-permanent Ponds and Lakes** are characterized by marsh vegetation, which dominates the central zone of the wetland, as well as coarse emergent plants or submerged aquatics, including cattails, bulrushes and pondweeds. These wetlands frequently maintain surface water throughout the growing season, i.e., from May to September.
- **Class 5 - Permanent Ponds and Lakes** have permanent open water in central zone that is generally devoid of vegetation. Submerged plants may be present in the deepest zone, while emergent plants are found along the edges. Plants commonly present in these wetlands include cattails, red swampfire and spiral ditchgrass.
- **Class 6 - Fen Ponds** are wetlands in which fen vegetation dominates the deepest portion of the wetland area. This wetland type often has wet meadow and low prairie vegetation present on the periphery. The soils are normally saturated by alkaline groundwater seepage. Fen ponds often have quaking or floating mats of emergent vegetation, which includes sedges, grasses and other herbaceous plants.

Upland — will be defined as the area contributing surface runoff to the wetland zone and is composed of the landscape that is upgradient of the toe slope, but does include the foot slope.

Wetland — in terms of wetland science, the wetland includes the area of the wetland basin and wetland margin. In the Wetlands Restoration Protocol, however, only the part of the wetland within the full supply level boundary is included in the calculation of offsets.

Wetland Basin — is the area extending from the centre of the wetland to the outer edge of the wet meadow zone. It is understood that the size and location of the wetland basin fluctuates within and among years depending on hydrologic condition (wet/dry periods) [up to and including the overflow/spill elevation].

Wetland Loss — includes infilling, altering, or physically draining the wetland, any transitory or permanent degradation of the wetland basin and/or margin, and any type of interference with the hydrology to and from the wetland.

Wetland Margin — is the area extending from the outer edge of the wetland basin to the outer edge of the toe slope or floodplain. The outer edge of the margin is delineated by the overflow/spill elevation, but the margin will be frequently, and perhaps predominately, non-submerged.

Wetland Restoration — re-establishment of a naturally occurring wetland with a functioning natural ecosystem whose characteristics are as close as possible to conditions prior to drainage or other alteration. Restoration activity thus includes:

- Reversal of drainage and filling;
- Termination of burning, clearing, and cultivating of the wetland margin;
- Improvement of management of the wetland margin; and
- Improvement of management of the upland.

Wetland restoration agency (WRA) — an organization responsible for restoring drained wetlands to near natural conditions. Responsibilities include securing land rights, obtaining approvals/licenses under authority of the Alberta *Water Act* and where applicable, the Alberta *Public Lands Act*, completing restoration works, operating and monitoring the restored wetlands, keeping records and reporting to Alberta Environment. Ducks Unlimited Canada is the primary WRA in Alberta. The Ducks Unlimited Canada procedures, systems, and controls are used as the frame of reference for wetlands delineation in this protocol.

2.0 Baseline Condition

The Wetlands Restoration Protocol will be implemented in a business-as-usual context where, in the absence of the projects, most freshwater mineral soil wetlands of the Prairie Pothole Region are expected to be degraded or drained (Dahl 2006, Euliss *et al.* 2006, Watmough and Schmoll 2007, Bartzen 2008). Indeed, at the Consultation Workshop for the development of the Wetlands Restoration Protocol, all of the assembled experts voted to accept the following statement:

> A large proportion of wetlands and associated uplands in the Prairie Pothole Region of Canada have been degraded as a result of landscape alteration and therefore it is reasonable to assume the vast majority wetlands in this region have been subjected to or are vulnerable to wetland loss.

No legislation requires land owners to restore previously drained wetlands. However, existing wetlands are protected under the Alberta Water Act. When existing wetlands are drained for non-agricultural development, the responsible developer must engage a Wetlands Restoration Agency to compensate for the drained wetland by restoring wetlands. Wetlands on agricultural land also are to some degree protected. Water cannot be drained off a quarter section, but wetlands on a single quarter section can be consolidated to decrease the wetland area on the quarter section.

The following information is provided to justify this selection:

1. Historical imagery acquired during or shortly after peak hydro periods (Late April through mid-June) are deemed optimal for interpreting wetland features. General heuristic for selecting candidate historical years of photography would be to target years with normal to above normal precipitation accumulations over hydrologic winter (October 1st through March 31st). Comparison of the annual precipitation accumulations over hydrologic winter relative to station normals should indicate which years of historical imagery are likely to document normal to above normal runoff events. Climate data for active and historical stations can be accessed via the internet at the Canada's National Data and Information Archive (http://www.climate.weatheroffice.gc.ca/Welcome_e.html);
2. Alberta Sustainable Resource and Development (ASRD) maintains the archive of all historical aerial photography captured for the Government of Alberta dating back to 1949. ASRD's Aerial Photo Record System (APRS) enables the query of the archive to determine the acquisition information of historical imagery for specific geographic locations. The most common scale of historical photography in the archive is 1:30,000, similar or larger scale photography is appropriate for interpreting Prairie wetlands and drainage features. Either digital scans or hard copy prints can be ordered and purchased through the website on a unit cost basis. APRS can be accessed via the internet at

http://www.srd.alberta.ca/MapsFormsPublications/AirPhotoDistribution/Default.aspx);

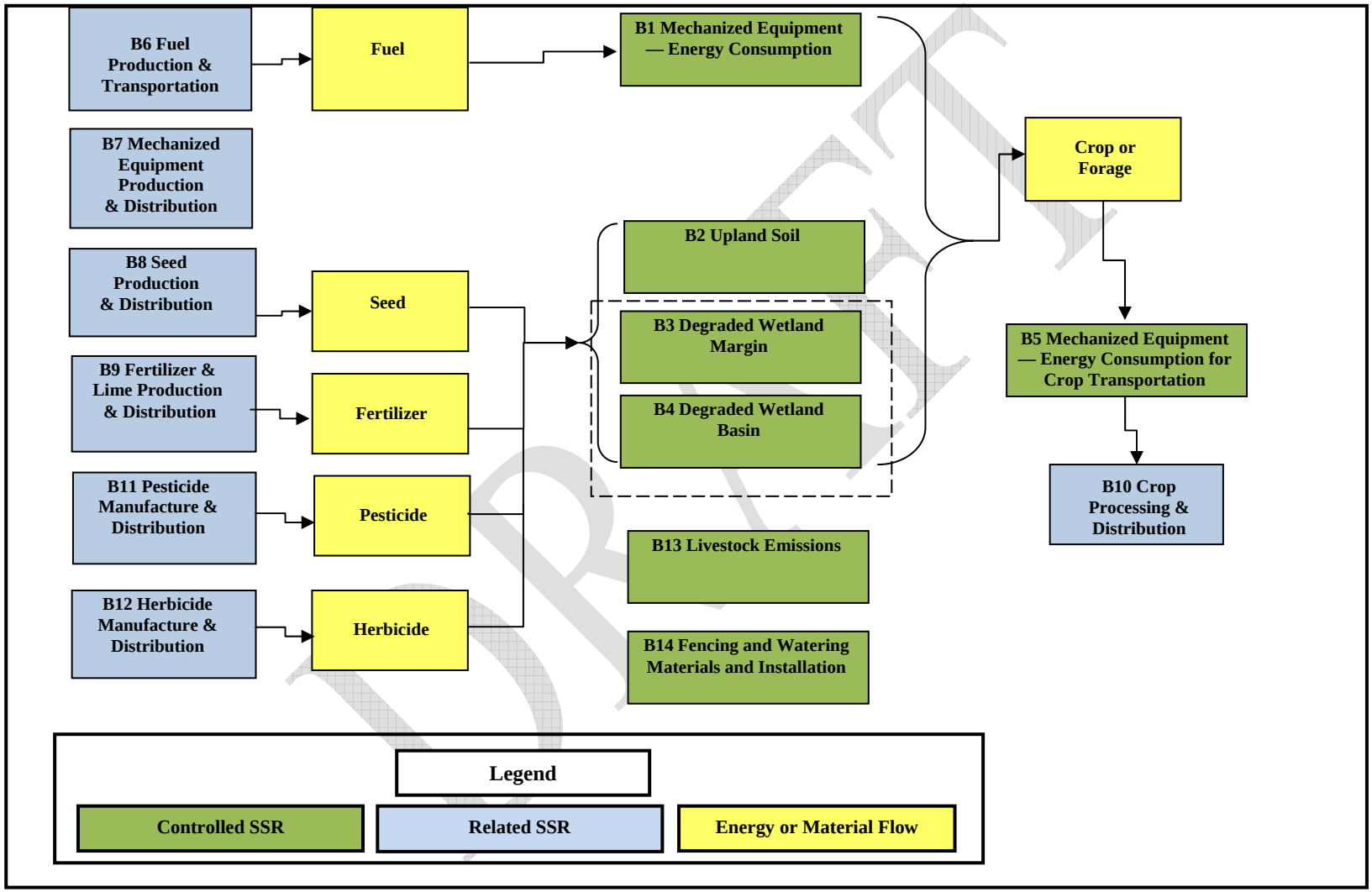
3. In areas where suitable provincial historical aerial photography is lacking, additional archival photo may be available in the National Air Photo Library (NAPL) available online at: http://airphotos.nrcan.gc.ca/photos_e.php. Geographic query is available to determine the availability of historical photo collected by the Government of Canada for specific areas of interest;

4. Ducks Unlimited already uses the historic benchmark approach for current restoration activities (Boychuk Pers. Comm., Pierce Pers. Comm.). Photogrammetric methods are used to analyze prospective wetlands by assessing the size and site characteristics recorded on aerial photographs from a number of years. Alternatively, inspection reports such as those described in Turner *et al.* (1987) and Bartzen (2008) from a number of years could be used to assess the baseline scenario for a wetland site proposed for restoration; and,

5. Further, the main threats to Prairie Pothole Region wetlands are drainage and land clearing. And, overgrazing and cultivation of riparian zones can directly impact the amount of vegetated habitat available to sequester carbon, but also has a negative impact on the remaining wetland due to the nutrient loading associated with surface runoff or groundwater discharge.

Figure 1 presents the process and material flow for the baseline condition.

Figure 1: Process Flow Diagram for the Project Baseline



2.1 Identification of Baseline Sources and Sinks

Sources and sinks for an activity are assessed based on Guidance provided by Environment Canada and are classified as follows:

Controlled: The behaviour or operation of a controlled source and/or sink is under the direction and influence of a Project Developer through financial, policy, management, or other instruments.

Related: A related source and/or sink has material and/or energy flows into, out of, or within a project but is not under the reasonable control of the project developer.

Affected: An affected source and/or sink is influenced by the project activity through changes in market demand or supply for projects or services associated with the project.

Baseline sources and/or sinks were identified by reviewing the relevant process flow diagrams, consulting with technical experts, national greenhouse gas inventory scientists and reviewing good practice guidance. This iterative process confirmed that the sources and/or sinks in the process flow diagrams covered the full scope of eligible project activities under the protocol.

Descriptions of each of the sources and/or sink and their classification as controlled, related, or affected are provided in Table 3.

Figure 2: Baseline Sources and Sinks for Wetlands Restoration

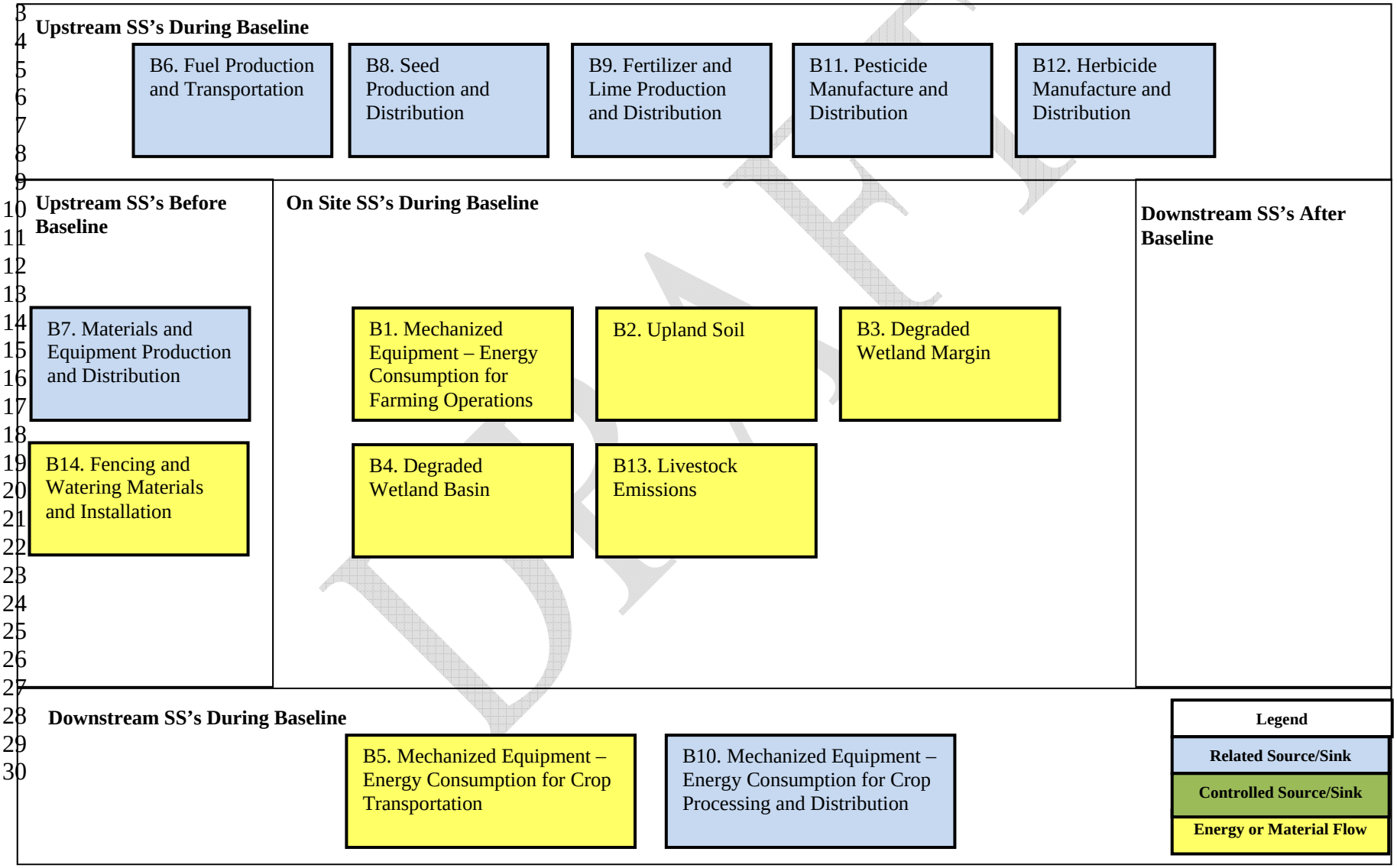


Table 3: Baseline Sources and Sinks

Sources/Sinks	Description	Controlled, Affected, Related
Upstream Sources and Sinks Before Project		
B7. Materials and Equipment Production and Distribution	GHG emissions of CO_2, CH_4 and N_2O are generated from the input of materials and energy in the manufacturing and distribution of materials and equipment.	Related
B14. Fencing and Watering Materials and Installation	GHG Emissions of CO_2, CH_4 and N_2O are associated with the energy and materials required to fence the land and install watering facilities.	Controlled
Upstream Sources and Sinks During Project		
B6. Fuel Production and Transportation	GHG emissions of CO_2, CH_4 and N_2O are associated with the offsite transportation of crop or crop products, including forages, to the point of sale or final use.	Related
B8. Seed Production and Distribution	GHG emissions of CO_2, CH_4 and N_2O are generated in the process of collecting, cleaning, storing and distributing seed for crops.	Related
B9. Fertilizer and Lime Production and Distribution	GHG emissions of CO_2, CH_4 and N_2O are associated with the manufacturing and distribution of fertilizer and lime.	Related
B11. Pesticide Manufacture and Distribution	GHG emissions of CO_2, CH_4 and N_2O are associated with the manufacture and off site transportation of pesticide.	Related
B12. Herbicide Manufacture and Distribution	GHG emissions of CO_2, CH_4 and N_2O are associated with the manufacture and off site transportation of herbicide.	Related
Onsite Sources and Sinks During Project		
B1. Mechanized Equipment – Energy Consumption for Farming Operations	GHG emissions of CO_2, CH_4 and N_2O are generated when mechanized equipment is used for cultivation, seeding, applying fertilizer, herbicide or pesticide, harvesting (swathing, combining, baling), and transporting crop products onsite. This SSR also includes emissions associated with equipment and energy needed, if any, to alter the natural landscape to drain wetlands (i.e. create drainage passages).	Controlled
B2. Upland Soil	GHG dynamics (net flux of CO_2, CH_4 and N_2O, and including net SOC sequestration if occurring) associated with upland soils. This soil may be cropped or in perennial forage.	Controlled
B3. Degraded Wetland Margin	GHG dynamics (net flux of CO_2, CH_4 and N_2O) associated with degraded margin soils.	Controlled
B4. Degraded Wetland Basin	GHG dynamics (net flux of CO_2, CH_4 and N_2O) associated with wetlands degraded and cropped.	Controlled
B13. Livestock Emissions	GHG emissions of N_2O and CH_4 and are associated with the manure of grazing animals. Enteric emissions of CH_4 are produced as a by-product of digestion that are exhaled or eructated from the grazing livestock.	Controlled
Downstream Sources and Sinks During Project		
B5. Mechanized Equipment –	GHG emissions of CO_2, CH_4 and N_2O are associated with the offsite transportation of	Controlled

Energy Consumption for Crop Transportation	crop or crop products, including forages, to the point of sale or final use.	
B10. Mechanized Equipment – Energy Consumption for Crop Processing and Distribution	GHG emissions associated with the cleaning, handling and final distribution of crop products, including forages.	Related
Downstream Sources and Sinks After Project		

1
2
3

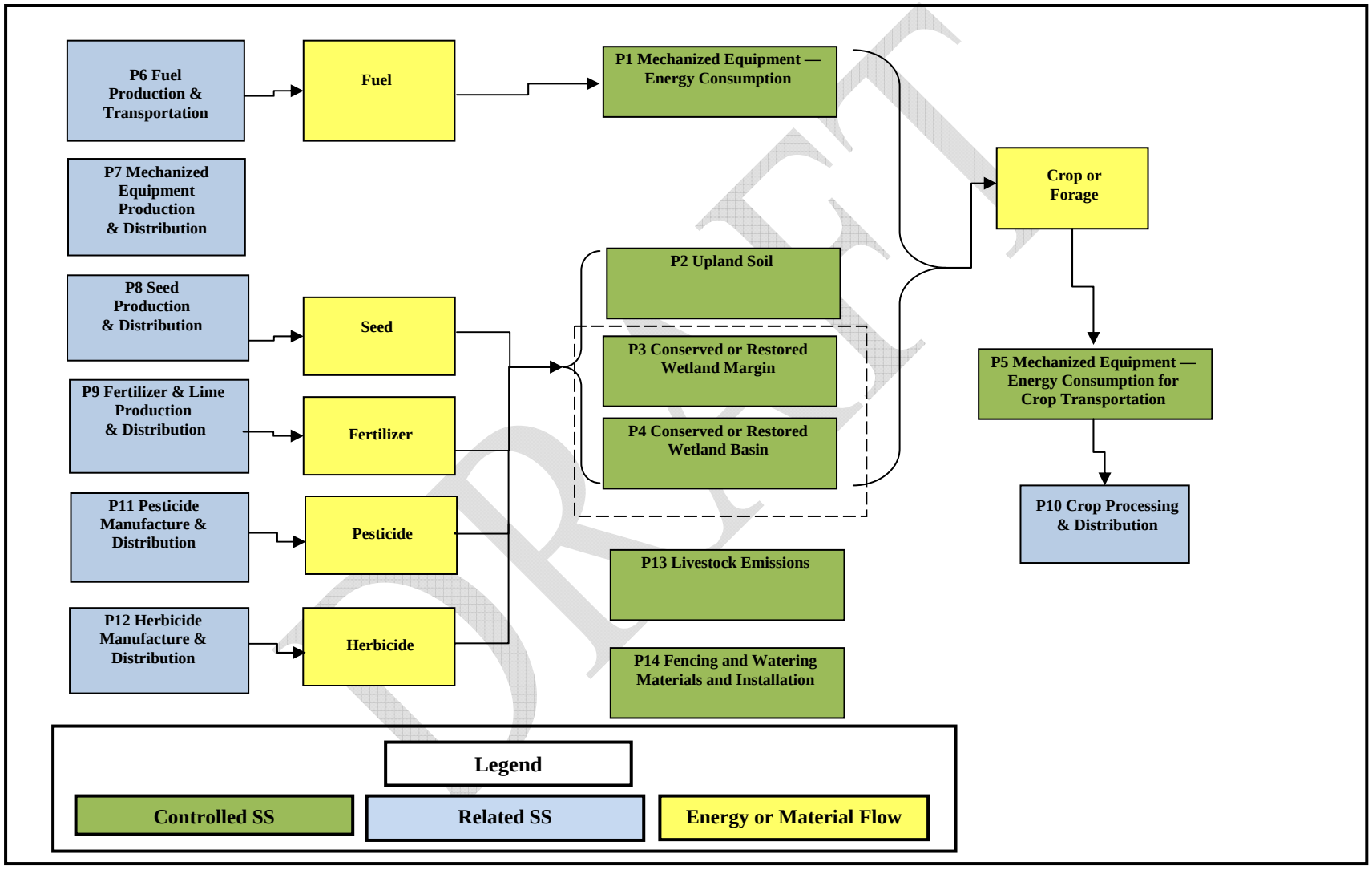
3.0 Project Condition

The project condition for the Wetlands protocol is a restored, functional wetland. The details of the project condition including the SSs, scope, boundaries, definitions of practices, risk of non-permanence, ownership, and project planning/landowner negotiations will all be detailed in the following subsections.

The project condition applies to drained freshwater mineral wetlands in the Prairie and Parkland Ecoregions of Alberta. Prior to the construction of agricultural drainage infrastructure these Seasonal to Permanent wetlands were closed basins forming internally drained areas that under normal conditions were isolated from natural external drainage systems. The project condition applies to the restoration of the wetland margin and wetland basin areas.

The soils in the margin area outside the full supply level and in the associated upland, although outside the direct boundaries of the Wetland Protocol, are "controlled" by the project and therefore should be managed accordingly. This margin and upland area will generally be under one of two regimes: 1) a cropped system, or 2) perennial forage. Mechanized equipment for farming operations (i.e. for hay harvesting and swathing/baling, as well as on-site transportation of the hay on the project site) is also considered an SS that is controlled by the project, and thus included within the scope of the project condition. This SS also includes emissions associated with the use of mechanized equipment to physically restore the natural landscape by installation of the earth plug. The other SS that is considered controlled by the project is mechanized equipment energy consumption for crop transportation. This SS includes the GHG emissions associated with the offsite transportation of crop or crop products, including forages, to the point of sale or final use.

Figure 3: Process Flow Diagram for the Project Condition



3.1 Identification of Project Sources and Sinks

Sources and sinks for the project were identified based on extensive scientific review. Sources and sinks were also identified for the project by reviewing good practice guidance, consulting with technical experts, national inventory scientists, and other relevant greenhouse gas technical sources. This iterative process confirmed that the sources and sinks in the process flow diagram (Figure 3) covered the full scope of eligible project activities under the protocol.

These sources and sinks have been further refined according to the life cycle categories identified in Figure 4. These sources and sinks were further classified as controlled, related, or affected as described in Table 4 below.

Figure 4: Project Conditions Sources and Sinks for Wetlands Restoration

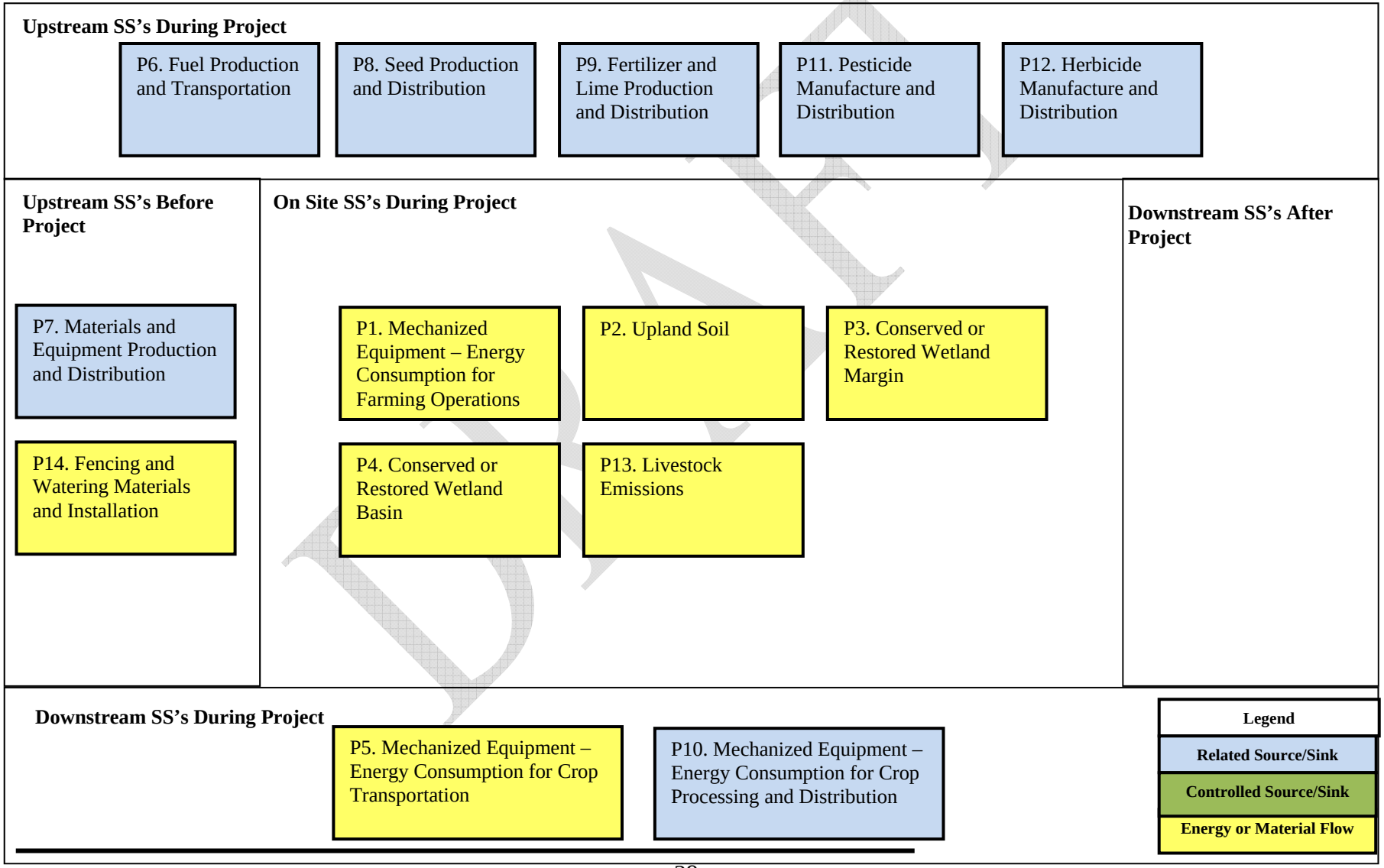


Table 4: Project Condition Sources and Sinks

Sources/Sinks	Description	Controlled, Affected, Related
Upstream Sources and Sinks Before Project		
P7. Materials and Equipment Production and Distribution	GHG emissions of CO_2, CH_4 and N_2O are generated from the input of materials and energy in the manufacturing and distribution of materials and equipment.	Related
P14. Fencing and Watering Materials and Installation	GHG Emissions of CO_2, CH_4 and N_2O are associated with the energy and materials required to fence the land and install watering facilities.	Controlled
Upstream Sources and Sinks During Project		
P6. Fuel Production and Transportation	GHG emissions of CO_2, CH_4 and N_2O are associated with the offsite transportation of crop or crop products, including forages, to the point of sale or final use.	Related
P8. Seed Production and Distribution	GHG emissions of CO_2, CH_4 and N_2O are generated in the process of collecting, cleaning, storing and distributing seed for crops.	Related
P9. Fertilizer and Lime Production and Distribution	GHG emissions of CO_2, CH_4 and N_2O are associated with the manufacturing and distribution of fertilizer and lime.	Related
P11. Pesticide Manufacture and Distribution	GHG emissions of CO_2, CH_4 and N_2O are associated with the manufacture and off site transportation of pesticide.	Related
P12. Herbicide Manufacture and Distribution	GHG emissions of CO_2, CH_4 and N_2O are associated with the manufacture and off site transportation of herbicide.	Related
Onsite Sources and Sinks During Project		
P1. Mechanized Equipment – Energy Consumption for Farming Operations	GHG emissions of CO_2, CH_4 and N_2O are generated when mechanized equipment is used for cultivation, seeding, applying fertilizer, herbicide or pesticide, harvesting (swathing, combining, baling), and transporting crop products onsite. This SSR also includes emissions associated with equipment and energy needed, if any, to alter the natural landscape to drain wetlands (i.e. create drainage passages).	Controlled
P2. Upland Soil	GHG dynamics (net flux of CO_2, CH_4 and N_2O, and including net SOC sequestration if occurring) associated with upland soils. This soil may be cropped or in perennial forage.	Controlled
P3. Conserved or Restored Wetland Margin	GHG dynamics (net flux of CO_2, CH_4 and N_2O, and including net SOC sequestration) associated with conserved or restored wetland margin.	Controlled
P4. Conserved or Restored Wetland Basin	GHG dynamics (net flux of CO_2, CH_4 and N_2O) of the conserved or restored wetland.	Controlled
P13. Livestock Emissions	GHG emissions of CH_4 and N_2O and are associated with the manure of grazing animals. Enteric emissions of CH_4 are produced as a by-product of digestion that are exhaled or eructated from the grazing livestock.	Controlled

Downstream Sources and Sinks During Project		
P5. Mechanized Equipment – Energy Consumption for Crop Transportation	GHG emissions of CO_2, CH_4 and N_2O are associated with the offsite transportation of crop or crop products, including forages, to the point of sale or final use.	Controlled
P10. Mechanized Equipment – Energy Consumption for Crop Processing and Distribution	GHG emissions associated with the cleaning, handling and final distribution of crop products, including forages.	Related
Downstream Sources and Sinks After Project		

3.2 Leakage

Two types of leakage are potentially associated with the restoration activity eligible under the Wetlands Restoration Protocol. First, there is potential for the activity of restoration of wetlands to increase the risk of degradation or drainage of other wetlands. Since most wetlands in the Prairie Pothole Region are considered to be already at least vulnerable to degradation or drainage, it is unlikely that the implementation of the Wetlands Restoration Protocol would increase the risk for the remaining wetlands to be drained. Second, there is potential for restoration of wetlands and associated uplands to result in the loss of cropland, and this potential loss could pressure conversion of grassland or forest land into cropland in other areas of the Prairie Pothole Region. Although the wetland areas and some of the upland areas will be removed from agricultural production (i.e. some uplands under Purchase Agreements or Conservation Easements may be left idle to maximize wildlife habitat), much of the uplands area are expected to be used for grazing, haying, and perhaps even for cropping. As the majority of the agricultural land in Alberta falls within the Prairie Pothole Region, it is unlikely that sufficient cropland could be idled under the Wetlands Restoration Protocol to influence land use patterns.

Despite the limited likelihood of leakage, the Wetlands Restoration Protocol incorporates elements to further minimize the risk of leakage. First, participants in the projects under the Wetlands Restoration Protocol shall enroll entire quarter sections into the project. This means that the entire quarter section on which the restored wetland(s) is (are) situated shall be subject to the post-restoration management prescribed by the Wetlands Restoration Protocol. Second, participants in the protocol projects have the option, in the 30-Year Wetlands Restoration Agreement, to continue raising crops.

3.3 Permanence

The design of the Wetlands Restoration Protocol is designed to address two types of risks to permanence of the net sequestration achieved by reversal of drainage of freshwater mineral soil wetlands in the Prairie Pothole Region. These two types of risks to permanence are: (1) reversal due to non-adherence to requirements of the Wetland Restoration Protocol; and, (2) reversal due to factors beyond the control of the Project Developer.

The Wetlands Restoration Protocol includes two elements to address the risk of reversal due to non-adherence to the protocol. First, the protocol requires projects to be administered by one of three types of land use agreements — purchase by conservation organization, Conservation Easement, or 30-Year Wetlands Restoration Agreement. In the experience of Ducks Unlimited Canada, the primary Wetlands Restoration Agency in Alberta, these types of agreements are not defaulted. Since the 1990's, Ducks Unlimited Canada has engaged in more than 600 conservation easement projects in Canada. There are no breaches of these agreements to date. This means the management conditions prescribed by the Wetlands Restoration Protocol are expected to be in place for at least the term of the 30-Year Wetlands Restoration Agreement. Second, the Protocol restored

wetlands (and existing wetlands on project participant's land) are protected according to the restrictions of the Alberta Water Act. The design of the Wetlands Restoration Protocol minimizes the risk of deliberate reversal of the project conditions prescribed by the protocol.

The major factor beyond the control of the Project Developer to consider is the risk of reversal due to long-term changes in water regime as a result of climate change. The Wetlands Restoration Protocol incorporates elements of conservativeness and discount to address the risk of increased water deficits in the Prairie Pothole Region of Alberta.

In part, the approach to derivation of the net sequestration coefficient used in the protocol addresses the risk associated with climate change. That is, the rate of soil organic carbon sequestration measured in the restored wetlands, which provide the basis for the coefficient, integrates the variability of water dynamics at the research sites. And, the CH_4 measurements and modeling used to adjust the soil organic carbon values to derive the net coefficient were recorded for submersed conditions. If submersed conditions become less prevalent in wetlands in the Prairie Pothole Region, rate of carbon sequestration may decrease, but CH_4 emissions may also decrease. Thus, the conservativeness in the net sequestration coefficient partly addresses this risk to permanence.

The conservativeness elements of the Wetlands Restoration Protocol and the restrictions of the Alberta Water Act provide substantive measures to deal with risks of intentional and environmental reversals of net carbon sequestration in freshwater mineral soil wetlands of the Prairie Pothole Region.

4.0 Quantification

GHG emissions from baseline scenario and project conditions are assessed against each other to quantify reductions. Sources and sinks are either included or excluded depending how they change in the project condition (wetland restoration) as compared to the baseline scenario. Sources that are not expected to change between baseline and project condition are excluded from the project condition. It is expected that excluded activities will result in the same or smaller level of emission in the project as compared to the baseline, and so it is conservative to exclude them.

All sources and sinks identified in Table 3 and Table 4 are listed in Table 5 below. Each source and sink is listed as include or excluded. Justification for these choices is provided.

Table 5: Comparison of Sources/Sinks for Baseline and Project

Identified Source and Sinks	Baseline (C, R, A)**	Project (C, R, A)**	Include or Exclude from Quantification	Justification for Inclusion / Exclusion
Onsite Sources and Sinks				
P1 Mechanized Equipment – Energy Consumption for Farming Operations	N/A	Controlled	Exclude	Excluded as the emissions from mechanized equipment used during farming are expected to be lower in the restored basin, and to remain unchanged or lower in the margin and associated upland. The conservativeness of this decision to exclude potential offsets from decreased use of mechanized equipment justifies exclusion of the small amount of fuel needed to install the earth plug.
B1 Mechanized Equipment – Energy Consumption for Farming Operations	Controlled	N/A	Exclude	
P2 Upland Soil	N/A	Controlled	Exclude	Excluded as the emissions from upland soils (e.g. cropland or perennial forage) may be regulated by another GHG protocol (e.g. Tillage Quantification Protocol) and thus outside this project boundary. It is important to avoid double counting.
B2 Upland Soil	Controlled	N/A	Exclude	
P3 Restored Wetland Margin	N/A	Controlled	Exclude	GHG dynamics (net flux of CO_2, CH_4 and N_2O, including net SOC sequestration) associated with degraded or restored wetland margins are ultimately controlled by the restoration practices. The derivation of the net sequestration coefficient for the Protocol included data points in the margin. But, to ensure rigor of documentation, the offsets generated in the wetland margin are not included. This results in conservative quantification of offsets.
B3 Degraded Wetland Margin	Controlled	N/A	Exclude	
P4 Restored Wetland Basin	N/A	Controlled	Include	Included within the wetlands restoration coefficient due to the GHG flux of the basin being altered between the degraded and restored state. GHG dynamics (net flux of CO_2, CH_4 and N_2O) are associated with wetlands that are degraded and cropped as well as restored.
B4 Degraded Wetland Basin	Controlled	N/A	Include	
P13 Livestock Emissions	N/A	Controlled	Exclude	Excluded as the emissions from livestock in the project condition are likely less than the baseline scenario. This is conservative. However, another GHG management protocol for uplands that accounts for emissions from livestock may be used with the Wetlands Restoration Protocol.
B13 Livestock Emissions	Controlled	N/A	Exclude	
Upstream Sources and Sinks				
P6 Fuel Production and Transportation	N/A	Related	Exclude	Excluded as the emissions from fuel production and transportation in the project condition are likely less than the baseline scenario. This is conservative.
B6 Fuel Production and Transportation	Related	N/A	Exclude	
P7Materials and Equipment	N/A	Related	Exclude	Excluded as emissions related to materials and equipment production and

Production and Distribution				distribution will be equivalent or higher in the baseline condition and are not considered. This is conservative.
B7 Materials and Equipment Production and Distribution	Related	N/A	Exclude	
P8 Seed Production and Distribution	N/A	Related	Exclude	Excluded as the emissions from seed production and distribution in the project condition are likely less than the baseline scenario. This is conservative.
B8 Seed Production and Distribution	Related	N/A	Exclude	
P9 Fertilizer and Lime Production and Distribution	N/A	Related	Exclude	Excluded as the emissions from fertilizer and lime production and distribution in the project condition are likely less than those in the baseline scenario (and therefore conservative) and may be regulated under an alternate GHG management protocol in the upland area.
B9 Fertilizer and Lime Production and Distribution	Related	N/A	Exclude	
P11 Pesticide Manufacture and Distribution	N/A	Related	Exclude	Excluded as the emissions from pesticide manufacture and distribution in the project condition are likely less than the baseline scenario. This is conservative.
B11 Pesticide Manufacture and Distribution	Related	N/A	Exclude	
P12 Herbicide Manufacture and Distribution	N/A	Related	Exclude	Excluded as the emissions from herbicide manufacture and distribution in the project condition are likely less than the baseline scenario. This is conservative.
B12 Herbicide Manufacture and Distribution	Related	N/A	Exclude	
P14 Fencing and Watering Materials and Installation	N/A	Controlled	Exclude	Excluded as emissions related to fencing and watering materials and installations in the project condition are equal to that which occurred in the baseline scenario.
B14 Fencing and Watering Materials and Installation	Controlled	N/A	Exclude	
Downstream Sources and Sinks				
P5 Mechanized Equipment – Energy Consumption for Crop Transportation	N/A	Controlled	Exclude	Excluded as these sources are outside the project boundary and may be subject to regulations imposed by upland GHG management protocols as discussed above. Not relevant to the project and should not change materially from the baseline and project conditions
P5 Mechanized Equipment – Energy Consumption for Crop Transportation	Controlled	N/A	Exclude	
P10 Mechanized Equipment – Energy Consumption for Crop Processing and Distribution	N/A	Related	Exclude	Excluded as the emissions from mechanized equipment energy consumption for crop processing and distribution in the project condition are likely less than the baseline scenario. This is conservative.
B10 Mechanized Equipment – Energy Consumption for Crop Processing and Distribution	Related	N/A	Exclude	

**Where C is Controlled, R is Related, and A is Affected.

4.1 Quantification Methodology

This protocol quantifies net GHG removal per hectare of restored Class 3, 4, and 5 wetlands in the Prairie Pothole Region of Alberta.

Quantifying emission reductions in the project involves determining the verifiable land area that will be restored, providing robust documentation to support the land area and size claim, and applying a reduction coefficient.

Quantifying emission reductions in the project condition involves:

1. Selecting the historical benchmark;
2. Topographic surveying of the potential wetland restoration area and physical earth plug construction;
3. Calculation of restored area using the 'Asbuilt' survey plan; and
4. Determining the carbon offset potential by multiplying the wetland restoration project land area by the reduction co-efficient;

Accounting for the total methane emissions, wetland restoration is a net sink for C, sequestering **0.88 Mg C ha^{-1} yr^{-1} or (3.25 Mg CO_2 eq. ha^{-1} yr^{-1}).**

The calculation of the carbon offset generated through restoration activities is determined by applying the net sequestration coefficient to the restored wetland basin area and margin defined in the Asbuilt survey geometry using the formula below:

Offset = (Wetland x NetSeq) x Nyears

NetSeq = Net sequestration coefficient 3.25 Mg CO_2eq ha^{-1} $year^{-1}$

Wetland = Total wetland area in hectares (area within fully supply level boundary).

Nyears = Duration of verification interval (Verification could be carried out annually, bi-annually, etc.).

4.1.1 Additional Quantification Explanation

Quantification Approach:

The following variables were assessed to determine the appropriate GHG reduction co-efficient for the restoration of class 3-5 wetlands in the Prairie Pothole Region (adapted from Badiou *et al*. 2010):

The net carbon sequestration from wetlands restoration is quantified with a coefficient derived from extensive research in the Prairie Pothole Region. Studies have consistently concluded freshwater mineral soil wetlands are carbon sinks (Gleason *et al.* 2005, Bedard-Haughn *et al.* 2006; Euliss *et al.* 2006). Recent studies have quantified the greenhouse gas flux from these systems (Phipps 2006, Hartwig 2008, Phillips and Beeri 2008, Gleason *et al.* 2009; Pennock *et al.* 2010). Badiou *et al.* (Submitted) integrated soil organic carbon and GHG flux data from 62 wetlands from 22 sites (22 wetlands never cultivated, 14 wetlands restored for less than 5 years, 26 wetlands restored for more than 5 years) to derive a net sequestration coefficient. Of these 62 wetlands, 29 are located in Alberta.

1. Climate data, wetland depth, and water chemistry:
    - Precipitation and air temperature from Environment Canada weather stations located near (within 35km) of the monitoring sites
    - Water samples from the basin centre of each wetland during late spring/early summer and early fall 2005
    - Samples were analyzed for total phosphate, ortho-phosphate, ammonium, nitrate-nitrite, conductivity, hardness, alkalinity as well as major anions and cations
2. Soil organic carbon (SOC):
    - SOC density assessed at all but three of the 62 wetland basins (soil cores taken at 6 duplicate landscape positions extending from the upland landscape position to the wetland basin and centre position.
    - For each increment, % moisture and bulk density were determined
    - SOC values were then determined by combustion at 840 ˚C using a LECO® CR-12 Carbon System (LECO Corporation, St. Joseph, MI).
3. GHG emissions and cumulative fluxes:
    - GHG samples were monitored on three different dates at 19 of the sites
    - At three sites (where wetland basins were monitored intensively) samples were collected at a minimum of 7 and maximum of 17 sampling dates
    - Soil gas sampling was conducted to determine GHG flux rates for each of the three wetlands situated at each of the three intensive monitoring sites
    - in order to estimate an annual cumulative flux for each site a daily mean GHG flux was determined based on the measured samples from each site
    - Further, cumulative fluxes of CH_4 and N_2O at the intensive sites were combined and expressed as CO_2 equivalents to determine the global warming potential (GWP) associated with these fluxes using a 100 year time horizon

- To account for methane emissions not captured in diffusive emissions measured from the surface of the centre of the basin (ebullition and plant-mediated emissions), total methane emissions were estimated using the Carnegie-Ames-Stanford model (Potter 1997, Potter *et al.* 2006). This model does not account for the decreased emissions of CH_4 expected in the sulphate-dominated wetlands of the Prairie Pothole Region, so this is another source of conservativeness in the Protocol quantification method.

Accounting for the total methane emissions, wetland restoration is a net sink for C, sequestering **0.88 Mg C/ha/yr or (3.25 Mg CO_2 eq./ha/yr)**.

Table 6: Quantification Methodology

Source/Sink	Parameter / Variable	Unit	Measured/ Estimated	Method	Frequency	Justify measurement or estimation and frequency
Project/Baseline Condition						
B4, Degraded Wetland Basin P4, Restored Wetland Area (inc. full supply level)	**Equation: Offset = (Wetland x NetSeq) x Nyears**					
	NetSeq – Net sequestration coefficient	Mg CO_2eq ha^{-1} $year^{-1}$	N/A – static value	N/A – static value	N/A – static value	Net coefficient for wetland restoration based on latest research in western Canada is 3.25 Mg CO_2eq ha^{-1} $year^{-1}$. To be re-visited at time of review of Protocol.
	Wetland – Total area within full supply level boundary	Ha	Measured	Using photogrammetric and geomatic techniques.-	N/A – static value, measured at time of restoration.	Methods for determining area of restored wetland (determined as full supply area) detailed in appended Procedures Manual
	Nyears – Duration of verification interval	Years	Measured	Records of restoration	Typically, annual verification interval.	Project Developers will choose appropriate verification intervals, but bi-annual monitoring of restored wetlands required.

5.0 Data Management

The Project Developer's data quality management system must meet regulatory quality standards to fulfill the quantification requirements of this protocol and ensure the offset credits meet the required level of assurance for compliance use in Alberta. The system must contain substantiated evidence including farm records corroborated by supporting documentation where possible.

The Project Developer shall establish and apply data quality management procedures to manage data and information. Written procedures must be established for each measurement task outlining responsibility, timing and record location requirements and should be discussed in the Offset Project Plan. Any changes in data retention, monitoring or other procedures, must be identified in the Offset Project Report compiled annually. The greater the rigour of the management system for the data, the more easily verification will be to conduct for the project.

5.1 Project Documentation

Minimum information required to support this activity is:

1. The name, contact information, and statement of qualifications of the Project Developer;
2. The name, contact information, and statement of credentials of the Wetlands Restoration Agency, including the credentials of participating QWAES, if any;
3. The name and contact information of the individual landowner(s) enrolled in the project;
4. The year the project was initiated;
5. The number, sizes, and locations of the degraded wetland areas enrolled in the project, including
    a. Legal land location (preferably GPS coordinates) of each degraded wetland;
    b. Field area substantiated with aerial photographs and a Wetlands Restoration Agency field visit;
    c. Evidence, substantiated by a Wetlands Restoration Agency, attesting to the depth of the wetland basin;
    d. An interim restoration plan assembled in a GIS environment;
    e. A survey, conducted by a Wetlands Restoration Agency, of the Asbuilt elevation of all earth plugs following construction; and
    f. Assemble all data into a standardized central repository (geospatial data archive) for future monitoring applications;

6. The plans for wetland and upland management, as well as the records of implementation of these plans.

The definitive reference for the restoration procedures and records prescribed by the Wetlands Restoration Protocol is the Procedures Manual (Boychuk 2010) of Ducks Unlimited Canada. The Procedures Manual is included in Appendix A of this protocol.

Alberta Environment requires that Project Developers maintain appropriate supporting information for the project, including all raw data for the project for a period of 7 years **after** the end of the project credit period. Where the Project Developer is different from the person implementing the activity, as in the case of an aggregated project[6], the individual landowner and the Wetlands Restoration Agency, must maintain sufficient records to support the Offset Project. The Project Developer and the Wetlands Restoration Agency must keep the information listed below and disclose all information to the verifier and/or government auditor upon request.

Record Keeping Requirements:

- Raw field measurements (proxy basin depth, size of degraded wetland, GPS co-ordinates for the interim restoration plan, notes on the viability of the site for restoration, dimensions of the earth plug, survey geometry, QWAES general notes, management data, independent variable data, and static factors within the measurement boundary);
- Digital scans and copies of all historical and present aerial photographs used;
- Topographic survey and earth plug construction data (including notes on; the earth plus location(s), the earth dam(s) geodetic elevation, flood contours, transect across the deepest portion of the wetland basin, the edge of the toe slope, earth plug construction, Asbuilt elevation of the earth plugs after restoration);
- A record of the Asbuilt survey/plan (electronic and hard copies);
- Completed interim plan (electronic and hard copies);
- Climate data records (if available and/or necessary);
- Light Detection and Ranging (LiDAR) imagery records (if used to identify potential drained wetland targets);
- GIS records (background data, potential scope of restoration information);
- A record of all adjustments made to raw data with justifications;
- All data and analysis used to support estimates and factors used for quantification;
- A record of changes in static factors along with all calculations for non-routine adjustments;

[6] Please see Alberta's Technical Guidance for Offset Project Developers http://environment.alberta.ca/02278.html

- Field visit activity logs, including assessment of wetland and upland; and
- Initial and annual verification records and audit results.

The following series of sub-sections are meant to provide examples of information that could be used to provide evidence for the data requirements of projects carried out according to the Wetlands Restoration Protocol. While these sub-sections provide illustrations of the potential sources and records of data, the Project Developer and Wetlands Restoration Agency will need to ensure the documentation collected will meet the requirements of verification.

5.1.1 Operational Records -- Wetland Restoration

The Project Developer and Wetlands Restoration Agency will prepare plans and maintain records detailing drained wetland target identification and the restoration procedures performed will be the primary target of the verifier's efforts to ensure the protocol has been implemented correctly. These records align with the reporting the Wetlands Agency needs to provide in fulfilling its role in the Alberta Wetlands Loss Compensation Program. These records should be maintained by the Project Developer and aggregator (if applicable), as well as the Wetlands Restoration Agency.

All records collected as part of the implementation of the restoration should be retained by all participants in the project (land owner, Project Developer, Wetlands Restoration Agency), and must be made available to the third party verifier. These records must be linked to the exact restoration procedures to support data management processes and systems designed and implemented according to scale of the wetland or digital field map as required.

These records include:

- Record of Assessment of Viability of Wetland for Restoration
    - Establish location of the historical basin edge, involving analysis of historical aerial photography and other concrete evidence, such as land-use management record or purchase agreements, with details of the previous ecological landscape;
    - If no definitive photogrammetric evidence, evidence of hydric soils via comprehensive soil sampling; and laboratory testing;
    - Measurement of maximum depth of basin (represents proxy for depth/permanence class);
    - Evidence that the surface or ground water was removed artificially that the spill elevation has been lowered, and that the restored wetland depth has the potential to be restored to a Class 3-5, lentic wetland;

- Assessment of the earth plug size and shape (to ensure it can manage the volume stored and outflow around the plug when water levels exceed full supply);
- Examine the back-flood area behind the earth dam and assess the potential of flooding adjacent properties upstream or the potential of causing downstream damages in the event of an earth plug failure;
- Determine the potential of a washing out of the structure from large meteorological events (examine the wetland morphology); and
- Determine the willingness of the landowner to change land use.

- Record of Project Planning and Landowner Negotiation
  - Obtain the consent of the landowner to conduct a visual change comparison (look at recent aerial photography);
  - Inspect the potential wetland restoration site on the ground the confirm the presence of a drain and the viability of restoration;
  - Conduct a field visit to confirm the definition of elements in the plan and to determine the viability of each site for restoration;
  - Assemble an interim restoration plan in a GIS environment, field notes and handheld GPS can be used to acquire additional data in the field, which will later be incorporated into the final interim plan), which includes;
  - Delineation of restored wetland basin extent derived from the historical benchmark aerial photography and wetland basin area — select photos (from ASRD's Aerial Photo Record System, the National Air Photo Library (NAPL), or otherwise) from years with normal to above normal precipitation accumulations over hydrologic winter (October 1st through March 31st);
  - Delineation of the wetland margin surrounding the wetland basin and wetland margin area.
  - Approximate locations of earth plugs.
  - Property lines and cadastral boundaries and appropriate labeling of legal land locations.
  - Identification and location of any potential obstacles to restoration (i.e. buildings) or hydrologic features that could influence the contributing area of restored wetlands (i.e. culvert locations).
  - Gain permission from the landowner to proceed with the restoration after incorporation of the field observations into the interim plan;
- Record of Topographic Survey and Earth Plug Construction

- Final visit to the site by Wetland Restoration Agency to formally survey the project area and construct earth plugs;
- Establish the earth plug location, spill elevation, and construction dimensions for each restored wetland;
- Establish the flood contour (wetland basin) topographically upstream of the earth plug spill elevation and demarcates the boundary on the ground;
- Generate a transect across the deepest portion of the wetland basin to establish maximum depth between basin bottom and the flood contour (This requirement confirms the permanence class of the restored wetland);
- Traverse and demarcate the edge of the toe slope around the restored wetland to establish the wetland margin area;
- Meet with the landowner on site to confirm the build prior to construction of the earth plugs;
- Supervise the construction of the earth plugs to insure they are in accordance to survey; and
- Survey the Asbuilt elevation of the plugs following construction.

- Record of Asbuilt Survey Plan
  - The Project Developer and the Wetland Restoration Agency (WRA), including legal name, address, and contact information of person responsible for project;
  - Wetland restoration project identification number;
  - Landowner name;
  - Legal Land Location;
  - Date of survey and construction;
  - Earth dam location and coordinates;
  - Earth dam geodetic elevation in meters;
  - Surveyed wetland basin boundary and area in hectares;
  - Surveyed wetland margin boundary and area in hectares; and
  - Total wetland area (basin and margin) in hectares.
- Record of Report to Geospatial Archive
  - This record will comprise the project data required for the Alberta Wetlands Loss Compensation program.

5.1.2 Operational Records -- Wetland and Upland Management

Management of the wetland according to the requirements of the Wetlands Restoration Protocol involves maintenance of the earth plug, and termination and prevention of burning, clearing, and cultivating of the wetland margin.

In projects administered under Conservation Easements, which prescribe 'no break, no drain' management, the land use agreement frames the management of the margin outside the full supply level and of the upland associated with the wetland.

For projects under 30-Year Wetland Restoration Agreements, which leave upland management to the discretion of the land owner, Project Developers must provide the plan to ensure management in the margin outside of the fully supply level and of the associated upland supports wetland function. This plan shall require landowners to maintain perennial cover by establishing grassland or forest land. Alternatively, if the land owner grows cultivated crops, the plan shall require landowner to fulfill the requirements of the 4R nitrogen management plan prescribed in the Agricultural Nitrous Oxide Emissions Reductions Protocol, and to use zero till as prescribed in the Tillage Quantification Protocol.

The operational records concerning wetland and upland management will include:

- Detailed wetland, margin, and upland management plans, signed by Wetlands Restoration Agency and land owner. In the case of annualcropping, the plans will include the Nitrogen Management Plans (with signature of Approved Professional Advisor) as required by the Agricultural Nitrous Oxide Emissions Reductions Protocol;
- Annual activity logs of all farming activity (cropping, grazing, haying) on wetland margins and associated uplands. These activity logs will be supported by purchase invoices for agricultural inputs and sales records of agricultural products; and
- Bi-annual inspection records for wetland and upland by Wetlands Restoration Agency (This inspection is required as part of the role of the Wetlands Restoration Agency in the Alberta Wetlands Loss Compensation program). The inspection records will include:
    - Inspection plan for earth dam integrity;
    - Inspection plan for wetland margin and restored wetland basin;
    - Inspection plan and list of survey equipment for ensuring the original construction elevation is maintained;
    - Repair plan in instances where the earth dam has washed out; and

- In addition to the records above, time-stamped digital photographs of the wetland are helpful for determining whether the integrity of the earth dam(s) have been compromised or when the elevation has been altered due to a wash out or other similar effect.

5.2 Record Keeping

The rigour and integrity of the record keeping for the Wetlands Restoration Protocol is enhanced by the credentials and capability of the organizations and professionals required to implement and monitor the prescribed activities and to administer the record keeping prescribed by the protocol.

Wetlands Restoration Agency:

The status of Wetlands Restoration Agency is conferred based on an assessment of an applicant organization by Alberta Environment. The assessment criteria include (but are not limited to): (1) capability to assume long-term liability of conservation and restoration agreements; (2) expertise to carry out delineation and restoration of wetlands; and (3) capability to report restoration activity to Alberta Environment.

The Wetlands Restoration Agency is a key participant in the planning and implementation of restoration in compensation for wetland loss due to land development under the requirements of the Alberta Wetland Loss Compensation activity regulated by Alberta Environment. The Wetlands Restoration Agency: (1) submits compensation proposals; (2) obtains long term (30 year) land interest; (3) completes restoration activity; and, (4) provides Alberta Environment with a wetland restoration inventory and an annual report on restoration activity.

The capabilities required for an organization to achieve the status Wetlands Restoration Agency, and the responsibilities a Wetlands Restoration Agency fills in the Alberta Wetland Loss Compensation activity, ensures that a Wetlands Restoration Agency is able to generate real, permanent, and verifiable offsets from wetlands restoration.

One of the means used by the Wetlands Restoration Agency to build the capabilities needed to fulfill its responsibilities is to hire Qualified Wetland Aquatic Environment Specialists.

Qualified Wetland Aquatic Environment Specialist (QWAES):

A QWAES is an expert with detailed knowledge of the aquatic environment, wetland soils, wetland species, hydrology and wetland margin habitat and their management or assessment. According to the Guide to the Code of Practice for Pipelines and Telecommunication Lines Crossing a Body of Water (Alberta Environment 2007a),

A "qualified aquatic environment specialist" means a person who:

(i) Possesses:

a. a post-secondary degree in biological sciences,
b. a technical diploma in biological sciences, or
c. educational equivalencies;

(ii) Has a detailed knowledge of the aquatic environment, including fish and fish habitat, management and assessment; and

(iii) Is currently experienced with:

a. fisheries and aquatic environment assessment methods, and
b. the determination of mitigation measures required to maintain the productive capacity of the aquatic environment, including fish habitats in Alberta that may be adversely affected by the carrying out of works in and adjacent to the water, bed and shore of water bodies

A qualified aquatic environment specialist may include a private individual, consultant or employee of a company that owns, plans or constructs pipeline crossings. The specifications and recommendations prepared by the qualified aquatic environment consultant under the Code of Practice would include but not be limited to mitigation and compensation measures related to the harmful alteration, disruption and destruction of fish habitat. The qualified aquatic environment specialist determines what information and assessments are needed to meet the requirement of the Code of Practice. In the event of enforcement actions resulting from contraventions of the Code of Practice, a qualified aquatic environment specialist should be able to defend and rationalize any specifications and recommendations prepared on behalf of the owner.

This description of QWAES is included as an example of the type of personnel a Wetlands Restoration Agency may employ — there is no requirement for the involvement of such personnel.

5.3 Site Visits

Monitoring of restored wetlands under the Alberta Offset System will require the Wetlands Restoration Agency to inspect the restoration project on a bi-annual basis. Monitoring will be primarily concerned with confirming the integrity of each earth dam and inspecting the wetland margin and restored wetland basin for non-compliant land use. Survey equipment may be required to determine if the original construction elevation is maintained. In instances where the earth dam has washed out or eroded, repairs will be required to rebuild the earth plug to original construction elevation.

Additionally, verifiers will typically request access to records, as well as do physical inspections[7] for wetland restoration practices, boundaries, and assessment of wetland and upland management practices. All landowners participating in an offset project should be prepared to receive a verifier. By having documentation on hand, such visits will be easily accommodated.

In order to support the third party verification and the potential supplemental government audit, the Project Developer must put in place a system that meets the following criteria:

- All records must be kept in areas that are easily located;
- All records must be legible, dated and revised as needed;
- All records must be maintained in an orderly manner;
- All documents must be retained for 7 years after the project crediting period;
- Electronic and paper documentation are both satisfactory; and
- Copies of records should be stored in two locations to prevent loss of data.

Note: Landowner and/or project developer attestations are not considered sufficient proof that an activity has taken place and do not meet verification requirements.

5.4 Quality Assurance/Quality Control Considerations

Quality Assurance/Quality Control can also be applied to add confidence that all measurements and calculations have been made correctly. These include, but are not limited to:

- Ensuring that the changes to operational procedures (including earth dam locations, wetland margin boundaries, etc.) continue to function as planned and achieve greenhouse gas reductions;
- Ensuring that the measurement and calculation system and greenhouse gas reduction reporting remains in place and accurate;
- Checking the validity of all data before it is processed, including static factors, and acquired data;
- Performing recalculations of quantification procedures to reduce the possibility of mathematical errors;
- Storing the data in its raw form so it can be retrieved for verification;
- Protecting records of data and documentation by keeping both a hard and soft copy of all documents;
- Recording and explaining any adjustment made to raw data in the associated report and files; and

[7] The site visits by verifiers are expected to be conducted according to samplings plans determined by the independent verification firms engaged by the Project Developer.

- A contingency plan for potential data loss.

5.5 Liability

Offset projects must be implemented according to the approved protocol and in accordance with government regulations. Alberta Environment reserves the right to audit Offset Credits and associated projects submitted to Alberta Environment for compliance under the *Specified Gas Emitters Regulation* and may request corrections based on audit findings.

6.0 References

The publications listed below represent the breadth and depth of scientific knowledge referenced to develop the technical foundation of the Wetlands Restoration Protocol. These publications provide the evidence deliberated in the Technical Background Document, support the considerations integrated in the Science Discussion Document, contribute to the decisions recorded in the Consultation Workshop Report, support the framework provided in the Technical Seed Document, and some are referenced in the Wetlands Restoration Protocol.

Adams, J. 2007. Effects of potential changes in nitrogen loads to nitrous oxide efflux from prairie potholes. Honours Thesis. Department of Biology.

Alberta Environment. 2007a. Guide to the Code of Practice for Pipelines and Telecommunication Lines Crossing a Body of Water. http://www3.gov.ab.ca/env/water/legislation/cop/pipeline.pdf.

Alberta Environment. 2007b. Provincial wetland restoration / compensation guide. ISBN 978-0-7785-5479-0 (On-line). http://environment.alberta.ca/documents/Provincial_Wetland_Restoration_Compensation_Guide_Feb_2007.pdf.

Alberta Water Council. 2008. DRAFT. Recommendations for a new Alberta wetland policy. www.AWChome.ca.

Austen, E. and A. Hanson. 2008. Identifying wetland compensation principles and mechanisms for Atlantic Canada using a Delphi approach. Wetlands. 28: 640–655.

Badiou, P., D. Pennock, and R. McDougal. 2008. Personal Communication. PowerPoint presentation to summarize results of Agriculture and Wetlands Greenhouse Gas Initiative research results Carbon sequestration and greenhouse gas emissions in Canadian prairie wetlands.

Badiou, P., R. McDougal, D. Pennock, and B. Clark. 2010. Greenhouse Gas Emissions and Carbon Sequestration Potential in Restored Wetlands of the Canadian Prairie Pothole Region. Submitted to J Wetland Ecol Manag.

Bartzen, B. 2008. Wetland characteristics and abundance of breeding ducks in prairie Canada . M.Sc. Thesis. University of Saskatchewan, Saskatoon.

Bedard-Haughn, A., F. Joengbloed, J. Akkerman, A. Uijl, E. de Jong, T. Yates, and D. Pennock. 2006. The effects of erosional and management history on soil organic carbon stores in ephemeral wetlands of hummocky agricultural landscapes. Geoderma. 135: 296-306.

Boychuk, L. Personal Communication. Manager of GIS and Inventory Programs. Ducks Unlimited Canada.

Boychuk, L. 2010. Procedures Manual. Ducks Unlimited Canada.

CCAR. 2009. Greenhouse Gas Mitigation Typology Issues Paper Tidal Wetlands Restoration. Prepared for California Climate Action Registry by Philip Williams & Associates Ltd with Science Applications International Corporation (SAIC). http://www.climateregistry.org/resources/docs/protocols/issue-papers/Tidal-Wetlands.pdf.

Corps of Engineers— Environmental Laboratory. 1987. Wetlands delineation manual. Technical Report Y-87-1. http://el.erdc.usace.army.mil/wetlands/pdfs/wlman87.pdf.

Cox, K.W., and A. Grose. 2000. Wetland mitigation in Canada: A framework for application. Issues Paper, No. 2000-1. North American Wetlands Conservation Council. ISBN: 0-662-28513-1.

Dahl, T.E. 1990. Wetlands losses in the United States 1780's to 1980's. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. Jamestown, ND: Northern Prairie Wildlife Research Center Online. http://www.npwrc.usgs.gov/resource/wetlands/wetloss/index.htm (Version 16JUL97).

Dahl, T.E. 2006. Status and trends of wetlands in the conterminous United States 1998 to 2004. Fish and Wildlife Service, US Department of the Interior, Washington, D.C. 112 pp. http://www.fws.gov/wetlands/_documents/gSandT/NationalReports/StatusTrendsWetlandsConterminousUS1998to2004.pdf.

Dahl, T.E. and M.D. Watmough. 2007. Current approaches to wetland status and trends monitoring in prairie Canada and the continental United States of America. Can. J. Remote Sensing. 33, Suppl. 1: S17-S27.

Driver, E.A. and D.G. Peden. 1977. The chemistry of surface water in prairie ponds. Hydrobiologia. 53: 33-48.

Ducks Unlimited Canada. 2008. The impacts of wetland loss in Manitoba. A brochure to describe the results of research in the Broughton's Creek watershed, published with participation of Agriculture and Agri-Food Canada, Environment Canada, and Natural Resources Canada.

Ducks Unlimited. 2009. Ducks Unlimited Avoided Grassland Conversion Project in the Prairie Pothole Region. Climate, Community, and Biodiversity Alliance Report. Prepared by Ducks Unlimited, Inc., New Forests, Inc. Equator, LLC. http://www.climate-standards.org/projects/files/20090323_du_agc_ccba_final_for_release.pdf.

Environment Canada. 1998. National sinks Table foundation Paper. Pollution Data Branch, Hull. http://www.ec.gc.ca/pdb/ghg/Related_Docs/sinks_found_e.cfm.

Environment Canada. 2008. National Inventory Report. Greenhouse Gas Sources and Sinks in Canada. 1990 – 2006. http://www.ec.gc.ca/pdb/GHG/inventory_report/2006_report/tdm-toc_eng.cfm.

Euliss Jr., N.H., R.A. Gleason, A. Olness, R.L. McDougal, H.R. Murkin, R.D. Robarts, R.A. Bourbonniere, and B.G. Warner. 2006. North American prairie wetlands are important non-forested land-based carbon storage sites. Sci. Total Environ. 361:179-188.

Euliss Jr., N.H., L.M. Smith, D.A. Wilcox, and B.A. Browne. 2008. Linking ecosystem processes with wetland management goals: Charting a course for a sustainable future. Wetlands 28: 553-562.

Gleason, R.A., M.K. Laubhan, and N.H. Euliss Jr., Eds. 2008. Ecosystem services derived from wetland conservation practices in the United States Prairie Pothole Region with an emphasis on the U.S. Department of Agriculture Conservation Reserve and Wetlands Reserve Programs: U.S. Geological Professional Paper 1745, 58 p.

Gleason, R.A., Euliss Jr., N.H., McDougal, R.L., Kermes, K.E., and E.N. Steadman. 2005. Potential of restored prairie wetlands in the glaciated North American prairie to sequester atmospheric carbon. Plains CO_2 Reduction (PCOR) Partnership.

Heagle, D.J. M. Hayashi, G. van der Kamp. 2007. Use of solute mass balance to quantify geochemical processes in a prairie recharge wetland. Wetlands. 27: 806-818.

Helgason, B.L. 2005. GHGFarm Version 1.0. An assessment tool for estimating net greenhouse gas emissions from Canadian farms. Agriculture and Agri-Food Canada, Lethbridge.

Houlahan, J.E. and C.S. Findlay. 2004. Estimating the 'critical' distance at which adjacent land-use degrades wetland water and sediment quality. Landscape Ecology. 19:677-690.

Jin, X., S. Wang, and Y. Zhou. 2008. Dynamic of organic matter in the heavy fraction after abandonment of cultivated wetlands. Biol. Fertil. Soils. 44: 997-1001.

Merbach, W., T. Kalettka, C. Rudat, and J. Augustin. 2002, Trace gas emissions from riparian areas of small eutrophic inland waters in northeast Germany, *in* Broll, G., Merbach, W., and Pfeiffer, E.V., eds., Wetlands in Central Europe: Soil organisms, soil ecological processes, and trace gas emissions. Berlin, Springer, p. 235–244.

Mitsch, W.J. and J.G. Gosselink. 2007. Wetlands, 4th ed., John Wiley & Sons, Inc., New York, 582 pp.

Myers, E.C. 2006. Climate Change and Forestry: A REDD Primer, The Ecosystem Marketplace, http://www.ecosystemmarketplace.com/pages/article.news.php?component_id=5797&component_version_id=8792&language_id=12.

Nelson, J. D. D., J. J. Schoenau, and S. S. Malhi. 2008. Soil organic carbon changes and distribution in cultivated and restored grassland soils in Saskatchewan. Nutr. Cycl. Agroecosyst. 82:137-148.

Offset Quality Initiative. 2008. Ensuring Offset Quality, Integrating High Quality Greenhouse Gas Offsets into North American Cap-and-Trade Policy. http://www.offsetqualityinitiative.org/pdfs/OQI_Ensuring_Offset_Quality_Exec_Sum_7_08.pdf.

Pena, N. 2009. Including peatlands in post-2012 climate agreements: Options and rationales. Report by Joanneum Research commissioned by Wetlands International. http://www.wetlands.org/LinkClick.aspx?fileticket=vDxo4SgYVXM%3d&tabid=56.

Pennock, D., T. Yates, A. Bedard-Haughn, K. Phipps, R. Farrell, and R. McDougal. 2010. Landscape controls on N_2O and CH_4 emissions from freshwater mineral soil wetlands of the Canadian Prairie Pothole region. Geoderma. 155:308-319.

Philips, R.L., Beeri, O., and E.S. DeKaiser. 2003. Soil trace gas flux for wetland vegetation zones in North Dakota prairie pothole basins. American Geophysical Union, Fall Meeting 2003, Abstract #B22A-0791.

Philips, R.L. and O. Beeri. 2007. The role of hydropedologic vegetation zones in greenhouse gas emissions for agricultural wetland landscapes. Catena. 72: 386-394.

Pierce, J. Personal Communication. Wildlife Biologist — Natural Advantage. Ducks Unlimited Canada.

Potter, C. S. 1997. An ecosystem simulation model for methane production and emission from wetlands. Global Biogeochemical Cycles 11:495-506.

Potter, C. S., S. Klooster, S. Hiatt, M. Fladeland, V. Genovese, and P. Gross. 2006. Methane Emissions from Natural Wetlands in the United States: Satellite-Derived Estimation Based on Ecosystem Carbon Cycling. Earth Interactions 10:1-12

Pritchard, D. 2009. Reducing emissions from deforestation and forest degradation in developing countries (REDD) - the link with wetlands. http://www.field.org.uk/files/WetlandsREDD_FINAL_26.3.pdf.

Ramsar Secretariat (2008): Additional information on climate change and wetlands issues. COP10 Information Paper DOC 25. http://www.ramsar.org/cop10/cop10_doc25_e.pdf.

Scholz, I. and L. Schmidt. 2008. Reducing Emissions from Deforestation and Forest Degradation in Developing Countries: Meeting the main challenges ahead. Briefing Paper 6/2008. German Development Institute.

Society of Wetland Scientists. 2000. Position paper on the definition of wetland restoration. http://www.sws.org/documents/positionpapers/restoration.pdf.

Stewart, R. E., and H. A. Kantrud. 1971. Classification of natural ponds and lakes in the glaciated prairie region. Resource Publication 92, Bureau of Sport Fisheries and Wildlife, U.S. Fish and Wildlife Service, Washington, D.C. www.npwrc.usgs.gov/resource/ wetlands/pondlake/ index.htm.

Terrestrial Carbon Group. 2008. How to include terrestrial carbon in developing nations in the overall climate change solution. www.terrestrialcarbon.org. ISBN 978-0-646-49550-7.

The Royal Society (2008): Biodiversity-climate interactions: adaptation, mitigation and human livelihoods. Report of an international meeting, London June 2007. The Royal Society, London. http://royalsociety.org/displaypagedoc.asp?id=29026.

Turner, B.C., G.S. Hochbaum, F.D. Caswell, and D.J. Nieman. 1987. Agricultural impacts on wetland habitats on the Canadian Prairies, 1981 – 1985. Transactions of the North American Wildlife and Natural Resources Conference. 52:207-215.

U.S. Fish and Wildlife Service and Canadian Wildlife Service. 1987. Standard operating procedures for aerial waterfowl breeding ground population and habitat surveys in North America. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C., USA and Environment Canada, Canadian Wildlife Service, Ottawa, Ontario, Canada.

van der Kamp, G. and M. Hayashi. 2009. Groundwater-wetland ecosystem interaction in the semiarid glaciated plains of North America. Hydrogeology Journal. 17: 203-214.

Voldseth, R. A., W. C. Johnson, T. Gilmanov, G. R. Guntenspergen, and B. V. Millett. 2007. Model estimation of land-use effects on water levels of northern prairie wetlands. Ecological Applications 17:527-540.

Watmough, M. D., and M. J. Schmoll. 2007. Environment Canada's Prairie & Northern Habitat Monitoring Program Phase II: Recent habitat trends in the PHJV. Technical Report Series No. 493. Environment Canada, Canadian Wildlife Service, Edmonton, Alberta, Canada.

Wetlands International. 2008. Sustaining and restoring wetlands: An effective climate change response. http://www.wetlands.org/Portals/0/publications/Brochure/wetlands_adaptation_press19aug.pdf.

Zimpfer, N.L., G.S. Zimmerman, E.D. Silverman, and M.D. Kone. 2008. Trends in Duck Breeding Populations, 1955-2008 - Administrative Report. U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Laurel, Maryland.

7.0 Appendix: Wetlands Restoration Procedures Manual

1 Intro

The purpose of this manual is to provide practical and repeatable technical guidelines necessary to define the extent of restored wetlands within the Alberta Offset System. Restored wetland area delineated using this methodology will serve as the basis to apply coefficients necessary to quantify GHG emission reductions associated with restoration of wetlands in the Prairie Pothole Region in Alberta. The application of the method will generate appropriate data to verify the location and extent of restored wetlands while establishing a baseline for compliance monitoring throughout the lifespan of the agreement with the landowner.

It is the objective of the manual to:

1. Present heuristic guidelines for establishing a historical benchmark and determining physical wetland restoration opportunities.
2. Present appropriate survey methods and specifications to accurately delineate restored wetlands for incorporation into the wetland protocol.
3. Establish a framework for capturing the 'Asbuilt' condition of restored wetlands appropriate to determine the carbon sequestration value of restored wetland within the protocol.
4. Provide wetland monitoring guidelines for insuring compliance on the restoration projects under the protocol

2 Scope

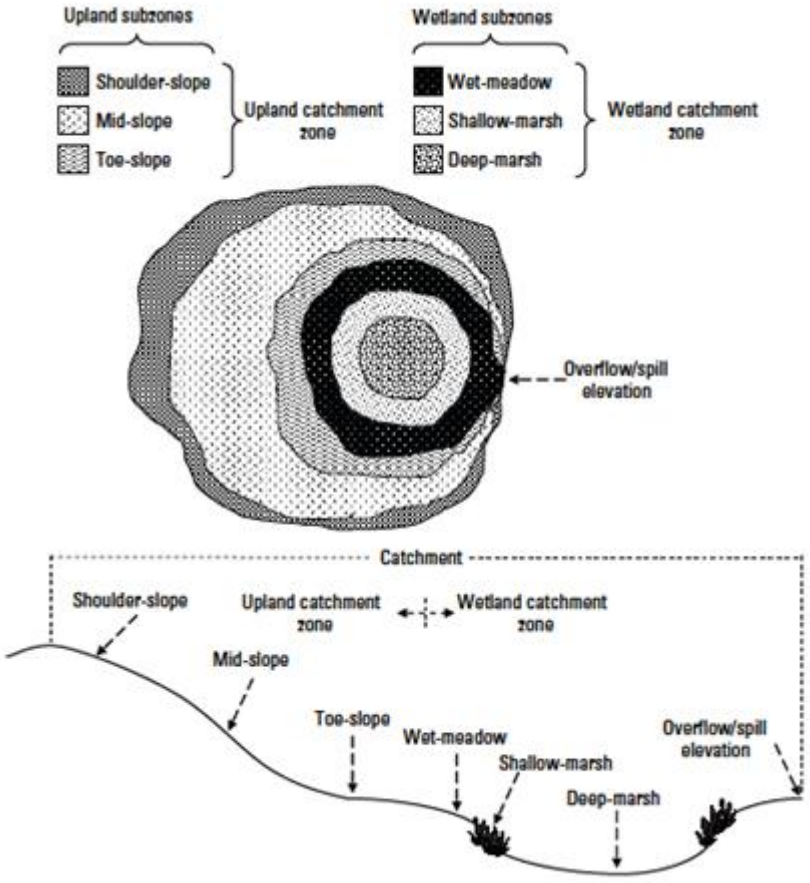
The scope of the procedures document applies to drained freshwater mineral wetlands (Lentic) in the Prairie and Parkland Ecoregions of Alberta. Prior to the construction of agricultural drainage infrastructure these Seasonal to Permanent wetlands were closed basins forming internally drained areas that under normal conditions were isolated from natural external drainage systems.

3 Wetland Definition

The functional definition of wetland basin within the scope of this manual is based on a geomorphic description that incorporates both topographic and vegetative indicators. Gleason et al. 2008 characterizes the entire wetland catchment or contributing area by distinguishing between upland and wetland zones. The **wetland basin** is defined as the entirety of the wetland zone extending outward from the deepest portion of the wetland to

the outer perimeter of the wet meadow zone. The wetland basin is comprised of the Deep Marsh, Shallow Marsh, and Wet-meadow wetland subzones and is subject to change in extent and composition in response to variable hydrologic conditions. As a functional definition within this manual the term **wetland** includes the wetland basin as well as the wetland margin that corresponds with outflow/spill elevation. (Figure 1) This topographic definition of **wetland** includes the wetland basin which is frequently inundated or saturated extending outward to the surrounding flood plain which is infrequently flooded or saturated in response to large meteorological events.

Figure 1: Wetland Definition



Adapted from Gleason et al. 2008.

The wetland water balance is controlled by redistribution of snow from adjacent uplands, incident precipitation, local runoff, evapotranspiration , groundwater exchange , and antecedent status of soil and depressional storage (Fang and Pomeroy, 2008; van der Kamp and Hayashi, 2009). Dependant on water balance, wetlands will vary from shallow and seasonal to deeper and relatively permanent (Pomeroy et el., 2009).

4 Drained Wetland Targets

A drained wetland occurs when surface or ground water has been removed by artificial means such that the area will no longer support hydrophytic vegetation (CE, 1987). The construction of drainage infrastructure into the wetland basin in effect lowers the spill elevation, altering the depressional storage capacity of the wetland, disrupting the natural flood regime of the wetland basin. This hydrologic disturbance alters the extent and duration of flooding and consequently removes the anaerobic soil conditions which support the hydrophytic communities within the wetland basin (CE, 1987).

From a wetland definition perspective the identification of drained wetlands remotely or in the field is difficult given that two primary indicators of wetland have been removed from the depression. Hydrologic indicators are only present for brief periods during large meterologic events and vegetation indicators can no longer persist in the altered hydrologic condition or have been directly removed by annual cultivation. Often, the only remaining indicator available to confirm the historical presence or to define historical wetland extent would be the presence and extent of hydric soils (CE, 1987). Comprehensive soil sampling as a means to locate drained wetlands is viewed as impractical for operational restoration. The practical alternative is to rely on historical aerial photography and field observations to determine the historical presence of a wetland basin and to estimate historical wetland extent (restoration potential).

The removal of key wetland indicators from the basin poses similar challenges for determining the permanence class achievable through restoration. Traditional field classification or typing of the wetland is not possible due to disruption of the hydrologic regime and consequently the removal of vegetation indicators. Thus, maximum depth of the wetland measured at the deepest portion of the basin represents a proxy for estimating the permanence class of restored wetlands. Table 1 presents the depth/permanence class relationship for establishing permanence of restored wetlands within the GHG Offset Protocol.

Table 1: *Restored Wetland Maximum Depth and Permanence Classification*

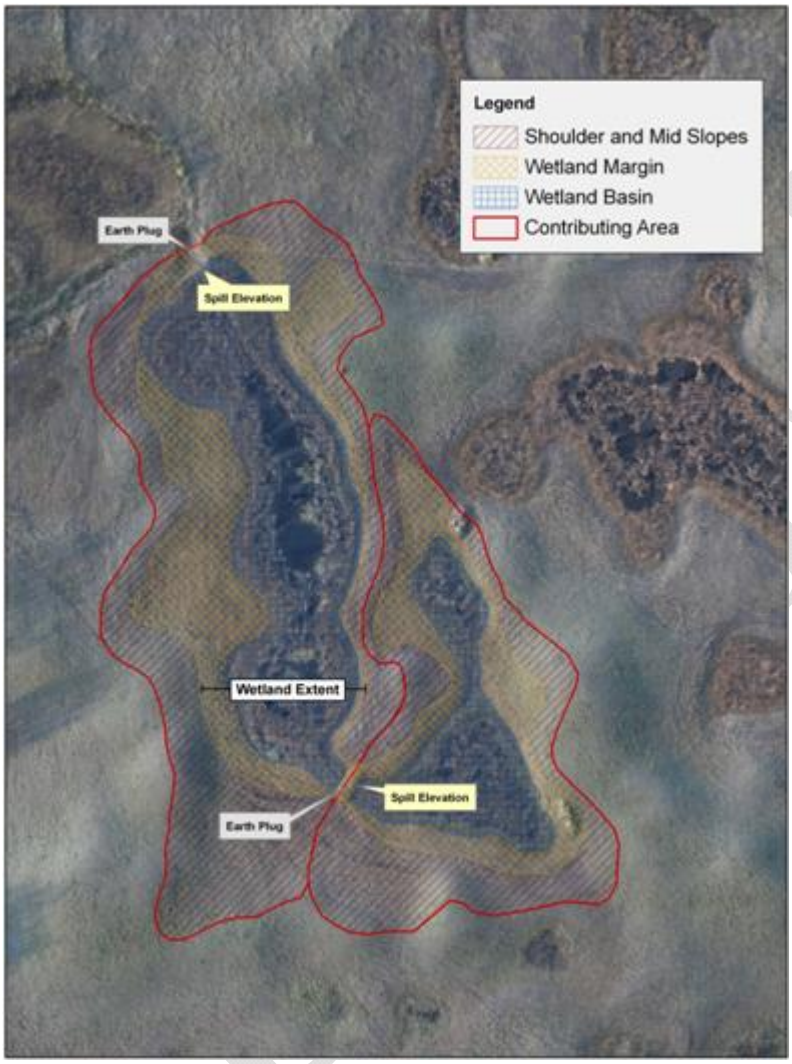
Depth (m)	**Steward and Kantrund Class**
0 - 0.10	Class I Ephemeral Pond
0.10 - 0.30	Class II Temporary Pond
0.30 - 0.60	Class III Seasonal Pond
> 0.60	Class IV & Class V Semi-Permanent/Permanent Pond

4.1 Intent of Wetland Restoration and Site Suitability

Intent of wetland restoration is to re-establish as close to possible the natural flood regime of the wetland. Construction of appropriately sized earth plugs at specific locations, graded to historical basin elevation will re-establish the flood regime of the wetland (Appendix A). The re-establishment of the flood regime over a period of years will

recreate anaerobic soil conditions and consequently re-establish the hydrophytic communities adapted to thrive in these environments. Figure 2 graphically illustrates the intent of restoration in conjunction with the wetland definition previously discussed.

Figure 2 *Restored Wetlands*



The viability of physical restoration must consider:

1. The location of the historical basin edge estimated through analysis of historical aerial photography, confirmed in the field using expert judgment by a qualified wetland restoration technician.
2. The depth of the drained wetland, expert judgment is required to determine if the restored wetland depth has the potential to be restored to Seasonal, Semi-permanent or Permanent wetland class as defined by (Stewart and Kandrund 1971).

3. The dimensions of earth plug required to re-establish hydrology at the historical basin margin confirmed in the field by a qualified wetland restoration specialist. The earth plug must be appropriately sized to manage the volume stored at full supply level at the historical basin margin.
4. The morphology of the wetland's contributing area and the potential for large meteorological events for washing out the structure. The earth plug must be appropriately sized to manage the volume stored anticipated to accumulate in large events. Furthermore, the earth plug must be appropriately shaped to allow outflow around the plug when stored water levels exceed full supply.
5. The size of the backflood area behind the earth dam and the potential to flood adjacent properties upstream and the potential to cause downstream damages in the event of earth plug failure.
6. The size of the wetland margin and the willingness of the landowner to change land use in conjunction with restoration of the basin area.

5 Wetland Restoration Workflow

The following sections build on existing operational procedures from a qualified Wetland Restoration Agency. The intent of following sections is to provide general workflow guidelines for:

- Identifying potential sites for physical restoration (historical to current conditions)
- Assembling the initial project plan and negotiating with the landowner.
- Conducting the field survey and documenting the construction of the restoration project.
- Compiling appropriate data for submission to the verifier for future compliance monitoring.

5.1 Locating Physical Restoration Opportunities

The most cost effective means of locating drained wetlands is through comparative analysis of historic and recent aerial photography. Visual comparison of a historical baseline captured prior to hydrologic impact is required to determine the historic location and extend of drained wetland basins.

5.1.1 Selection of the Historical Benchmark

Historical imagery acquired during or shortly after peak hydro periods (Late April through mid-June) are deemed optimal for interpreting wetland features. General heuristic for selecting candidate historical years of photography would be to target years with normal to above normal precipitation accumulations over hydrologic winter (October 1st through March 31st). Comparison of the annual precipitation accumulations over hydrologic winter relative to station normals should indicate which years of

historical imagery are likely to document normal to above normal runoff events. Climate data for active and historical stations can be accessed via the internet at the Canada's National Data and Information Archive (http://www.climate.weatheroffice.gc.ca/Welcome_e.html)

Alberta Sustainable Resource and Development (ASRD) maintains the archive of all historical aerial photography captured for the Government of Alberta dating back to 1949. ASRD's Aerial Photo Record System (APRS) enables the query of the archive to determine the acquisition information of historical imagery for specific geographic locations. The most common scale of historical photography in the archive is 1:30,000, similar or larger scale photography is appropriate for interpreting Prairie wetlands and drainage features. Either digital scans or hard copy prints can be ordered and purchased through the website on a unit cost basis. APRS can be accessed via the internet at http://www.srd.alberta.ca/MapsFormsPublications/AirPhotoDistribution/Default.aspx).

In areas where suitable provincial historical aerial photography is lacking, additional archival photo may be available in the National Air Photo Library (NAPL) available online at: http://airphotos.nrcan.gc.ca/photos_e.php. Geographic query is available to determine the availability of historical photo collected by the Government of Canada for specific areas of interest.

5.1.2 Project Planning and Landowner Negotiations

With the consent of a willing landowner visual change detection comparing historical photography to recent aerial imagery will identify wetlands that have been converted to annual cultivation on a prospective property. The interpreter attempts to identify wetlands that were present in the historical photograph and are now absent in the current imagery. The interpreter will also attempt to determine if observed change is transitory (i.e. cultivation of ephemeral wetland) or more permanent due to hydrologic alteration which is indicated by the presence of drains breaching the wetland basin. Often large drainage works or recently constructed (or maintained) drains will be visible in the current photography making it possible to confirm the drainage of wetland basins remotely. However, it is more common for drains to appear subtlety in gentle topography or to be masked by often years (decades) of annual cultivation. Regardless of the circumstances, potential wetland restoration sites must be inspected on the ground by a qualified restoration technician to confirm the presence of a drain and to establish the viability of restoration as stated in **Section 4.1**.

Light Detection and Ranging (LiDAR) "Bare Earth" imagery in conjunction with historical air photos also has the potential to identify drained wetlands. Similar visual change detection techniques using derivative hillshade surfaces and historical aerial photographs can be used to determine the extent of historical wetlands and can be very effective at identifying drainage features. Historical wetland basin margins can be identified visually and defined from LiDAR elevation surfaces via "contouring" with

reasonable precision. However, the significant cost associated with purchase of LiDAR is viewed as impractical for identification of drained wetlands within the protocol.

Creation of digital plans within a Geographic Information System (GIS) is an effective means of compiling appropriate background data; estimating the potential scope of restoration; communicating project extent to landowners; and efficiently adapting the plan to meet landowner requirements. Prior to the initial field visit a technician is required to assemble an interim restoration plan in a GIS environment. The elements of the interim plan are:

1. Delineation of restored wetland basin extent derived from the historical benchmark aerial photography and wetland basin area.
2. Delineation of the wetland margin surrounding the wetland basin and wetland margin area.
3. Approximate locations of earth plugs.
4. Property lines and cadastral boundaries and appropriate labeling of legal land locations.
5. Identification and location of any potential obstacles to restoration (ie. buildings) or hydrologic features that could influence the contributing area of restored wetlands (ie. culvert locations).

Field visit is required to confirm the definition of elements in the plan and to determine the viability of each site for restoration following the guidelines in **section 4.1**. Field notes and hand held GPS can be used to acquire additional data in the field which will later be incorporated into the final interim plan. Following incorporation of the field observations into the interim plan the area affected by restoration can be communicated to the landowner to gain permission to proceed with the build.

5.2 Topographic Survey and Physical Earth Plug Construction

The final visit to the site is conducted by the wetland restoration technician and a survey technician to formally survey the project and construct earth plugs. Working from the completed interim plan the survey technician is required to conduct the following tasks to survey specifications in Appendix B:

1. Establish the earth plug location, spill elevation, and construction dimensions for each restored wetland.
2. Establishes the flood contour (wetland basin) topographically upstream of the earth plug spill elevation and demarcates the boundary on the ground.
3. Generate a transect across the deepest portion of the wetland basin to establish maximum depth between basin bottom and the flood contour. This is a requirement to confirm the permanence class of the restored wetland.

4. Traverse and demarcate the edge of the toe slope around the restored wetland to establish the wetland margin area.
5. Meet with the landowner on site to confirm the build prior to construction of the earth plugs.
6. Supervise the construction of the earth plugs to insure they are in accordance to survey.
7. Survey the Asbuilt elevation of the plugs following construction.

Following construction, both the earth plug and wetland margin are to be seeded with varieties approved for use in wetland restorations as listed in Appendix C.

5.3 Compilation of Asbuilt Survey Plan

Following completion of restoration activities on the ground the survey technician is responsible for compiling an Asbuilt plan to formally document the restoration project. Survey geometry gathered in the field is compiled into a standardized plan that contains specific content and plan free information to authenticate the restoration. The Asbuilt plan is to be submitted to the verifier as a requirement under GHG Offset Protocol.

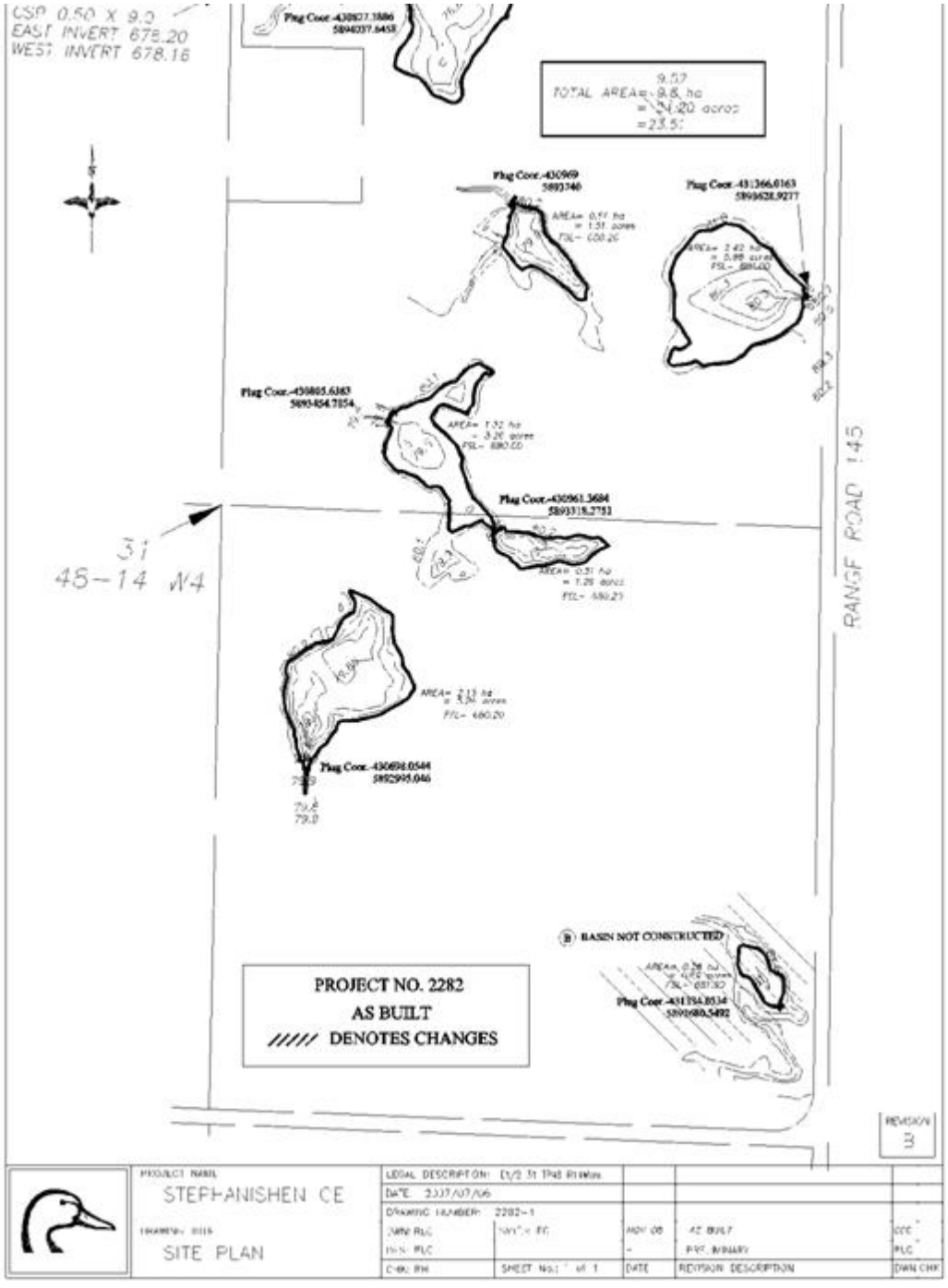
The following plan free information is required in the Asbuilt plan:

- The project proponent or the Wetland Restoration Agency (WRA)
- Wetland restoration project identification number
- Landowner name
- Legal Land Location
- Date of survey and construction

The following content is to be contained within the body of the Asbuilt Plan:

- Earth dam location and coordinates
- Earth dam geodetic elevation in meters
- Surveyed wetland basin boundary and area in hectares.
- Surveyed wetland margin boundary and area in hectares
- Total wetland basin area and wetland margin area in hectares

Figure 3: *Representative Asbuilt Plan*



5.4 Determination of Carbon Offset

The calculation of the carbon offset generated through restoration activities is determined by applying the net sequestration coefficient (ClimateCheck, 2010) to the restored wetland basin area and margin defined in the Asbuilt survey geometry using the formula below:

NetSeq = Net sequestration coefficient 3.25 Mg CO_2eq ha^{-1} $year^{-1}$

WetBasin = Total wetland basin area in hectares, defined as area within the fully supply level boundary.

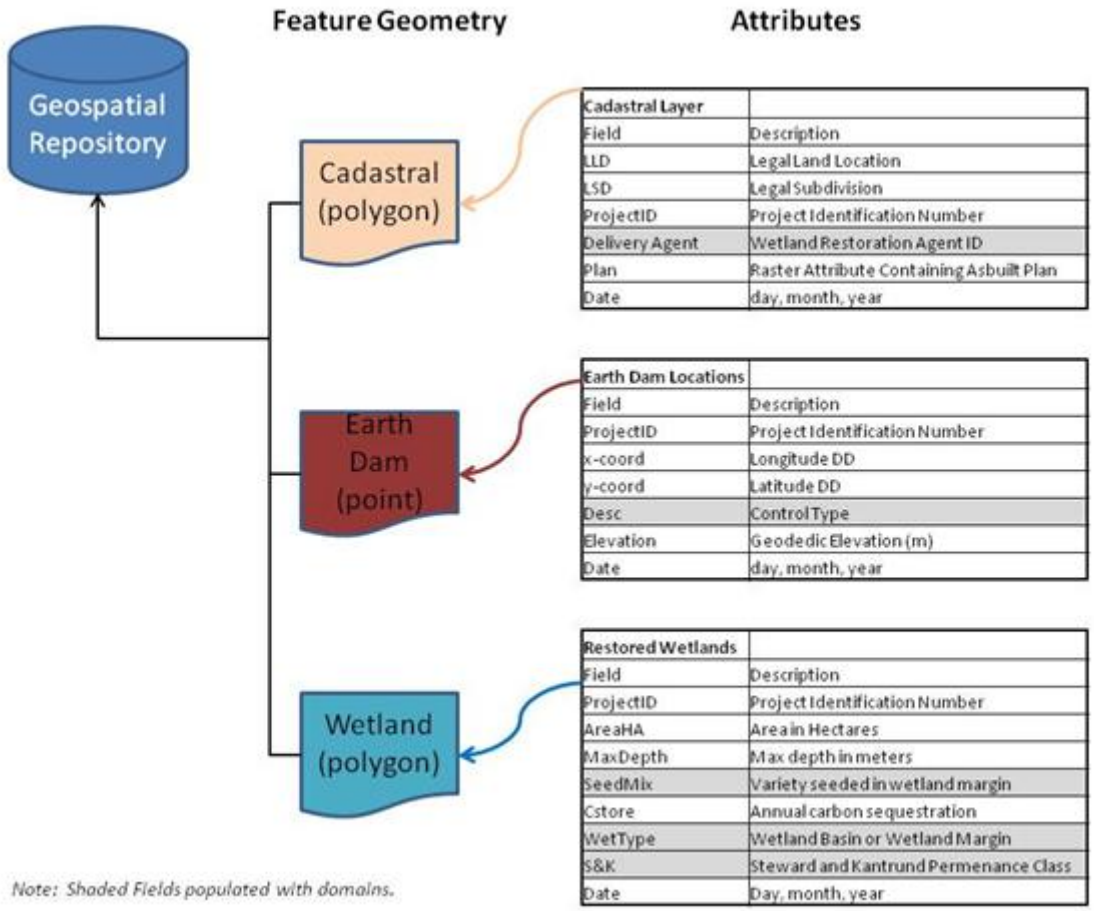
Nyears = Duration of agreement with landowner in years.

Offset = (WetBasin x NetSeq)] x Nyears

5.5 Compilation of Geospatial Data Archive

As a baseline for monitoring the project throughout the lifespan of the agreement the delivery agent is required to submit standardized data to the verifier. The assembly of all project data into a standardized central repository will facilitate efficient retrieval of relevant information for future monitoring applications. Ancillary data and survey geometry are to be compiled and submitted in accordance with the following data model for incorporation into a provincial data repository:

Figure 4: *Data Schema for Restored Wetland Information*



Cadastral Layer	
Field	Description
LLD	Legal Land Location
LSD	Legal Subdivision
ProjectID	Project Identification Number
Delivery Agent	Wetland Restoration Agent ID
Plan	Raster Attribute Containing Asbuilt Plan
Date	day, month, year

Earth Dam Locations	
Field	Description
ProjectID	Project Identification Number
x-coord	Longitude DD
y-coord	Latitude DD
Desc	Control Type
Elevation	Geodedic Elevation (m)
Date	day, month, year

Restored Wetlands	
Field	Description
ProjectID	Project Identification Number
AreaHA	Area in Hectares
MaxDepth	Max depth in meters
SeedMix	Variety seeded in wetland margin
Cstore	Annual carbon sequestration
WetType	Wetland Basin or Wetland Margin
S&K	Steward and Kantrund Permenance Class
Date	Day, month, year

Submission of geospatial data to the provincial repository requires that each feature class conform to GOA metadata standards as defined by "Information Sharing Initiative, Phase II, Geospatial Metadata Best Practices" v. 1.5 (ASRD, 2009). Geospatial data submitted to the repository must also be projected from survey coordinates to GOA provincial standard reference system below:

Projection: Transverse Mercator (AB 10TM)

False Easting: 500000

False Northing: 0

Central Meridian: -115 00 00

Scale Factor: .9992

Latitude of Origin: 0 00 00

Linear Unit: Meters

Prime Meridian: Greenwich (0)

Datum: North American 1983

Spheroid: GRS1980

6 Monitoring Requirements

Monitoring of restored wetlands under the GHG Offset System will required the verifier to inspect the restoration project on a bi-annual basis. Monitoring will be primarily concerned with confirming the integrity of each earth dam and inspecting the wetland margin and restored wetland basin for non-compliant land use. Survey equipment may be required to determine if the original construction elevation is maintained. In instances where the earth dam has washed out or eroded, repairs will be required to rebuild the earth plug to original construction elevation.

7 References

Alberta Sustainable Resource Development, 2009. "Information Sharing Initiative, Phase II, Geospatial Metadata Best Practices" v. 1.5, Sustainable Resources and Environmental Management, Geographic Information Management Working Group. Government of Alberta.

Alberta Sustainable Resource Development, 2008. "File GeoDatabase Specifications" v. 1.0., Geographic Information Office (GIO), Strategic Support and Integration Division.

Alberta Sustainable Resource Development, 2007. Alberta Survey Control Products Manual. Lands Division, Lands Dispositions Branch, Geodetic Control Unit. Government of Alberta.

ClimateCheck, 2010. Progress Report: Results of Consultation Workshop for Wetlands Conservation and Restoration Protocol. Submitted to Climate Change Central and Ducks Unlimited Canada. April, 30, 2010.

Fang, X and Pomeroy, J. W. 2008. Drought Impacts on Canadian prairie wetland snow Hydrology. *Hydrological Processes* **22**: 2594-2609.

Gleason, R.A., M.K. Laubhan, and N.H. Euliss Jr., Eds. 2008. Ecosystem services derived from wetland conservation practices in the United States Prairie Pothole Region

with an emphasis on the U.S. Department of Agriculture Conservation Reserve and Wetlands Reserve Programs: U.S. Geological Professional Paper 1745, 58 p.

Pomeroy, John; Fang, Xing; Westbrook, Cherie; Minke, Adam; Guo, Xulin; Brown, Tom. 2009. *Prairie Hydrological Model Study Final Report*; Centre for Hydrology Report #7; University of Saskatchewan; Saskatoon, Saskatchewan. December 21, 2009.

U.S Army Corps of Engineers. 1987. Wetlands Delineation Manual Final Report. Technical Report Y-87-1, January, 1987. Waterways Experiment Station, Vicksburg, MS.

Van der kamp, G. Hyashi, M. 2009. Groundwater-wetland ecosystem interaction in the semiarid glaciated plains of North America. *Hydrogeology Journal* **17**: 203-214.

Procedures Document - Appendix A Earth Plug Construction Guidelines

All earth plugs should be constructed under the general supervision of qualified engineering staff with adequate experience in water resource and geotechnical applications.

Work must be completed in accordance with all applicable authorizations and permits. Authorization may be required under the Alberta Water Act and other legislation. The responsible agency should be contacted for details.

These guidelines apply only to small wetlands (less than 1 ha. surface area and a drainage area of less than 5 ha.) that have been drained by surface disturbances. Larger wetlands, wetlands with groundwater discharges (springs), and wetland creation require special engineering considerations. Site specific designs completed under the supervision of qualified engineering staff should include peak flow estimates, calculated velocities, and erosion resistant measures.

Re-contouring is the construction of an earthen dam (earth plug) which restores a drained wetland to its natural water level or below. It is important that prior to this type of restoration, the area has been reviewed and the drainage area determined as local and not extensive (less than 5 ha.). Earth plugs may not be adequate in areas which are subject larger flows due to hydrological regimes that are not typical of Alberta prairie and parkland conditions. Earth plugs may not be adequate if good mineral soil borrow is not available. Prior to construction it must be determined that the wetland will not impact upstream or downstream infrastructure. Earth plugs are only appropriate where a failure would not present any significant hazard.

These construction guidelines are similar to dam, dyke or berm construction.

1. Stake the two end points establishing the elevation of the plug.

2. Strip and stockpile topsoil from within the proposed earthen plug area.

    a. Strip enough topsoil to sufficiently cover the earthen plug
    b. Excavate a standard key trench 1m x 1m x 1:1 slopes
    The key trench material can be turned over within the trench and re-compacted

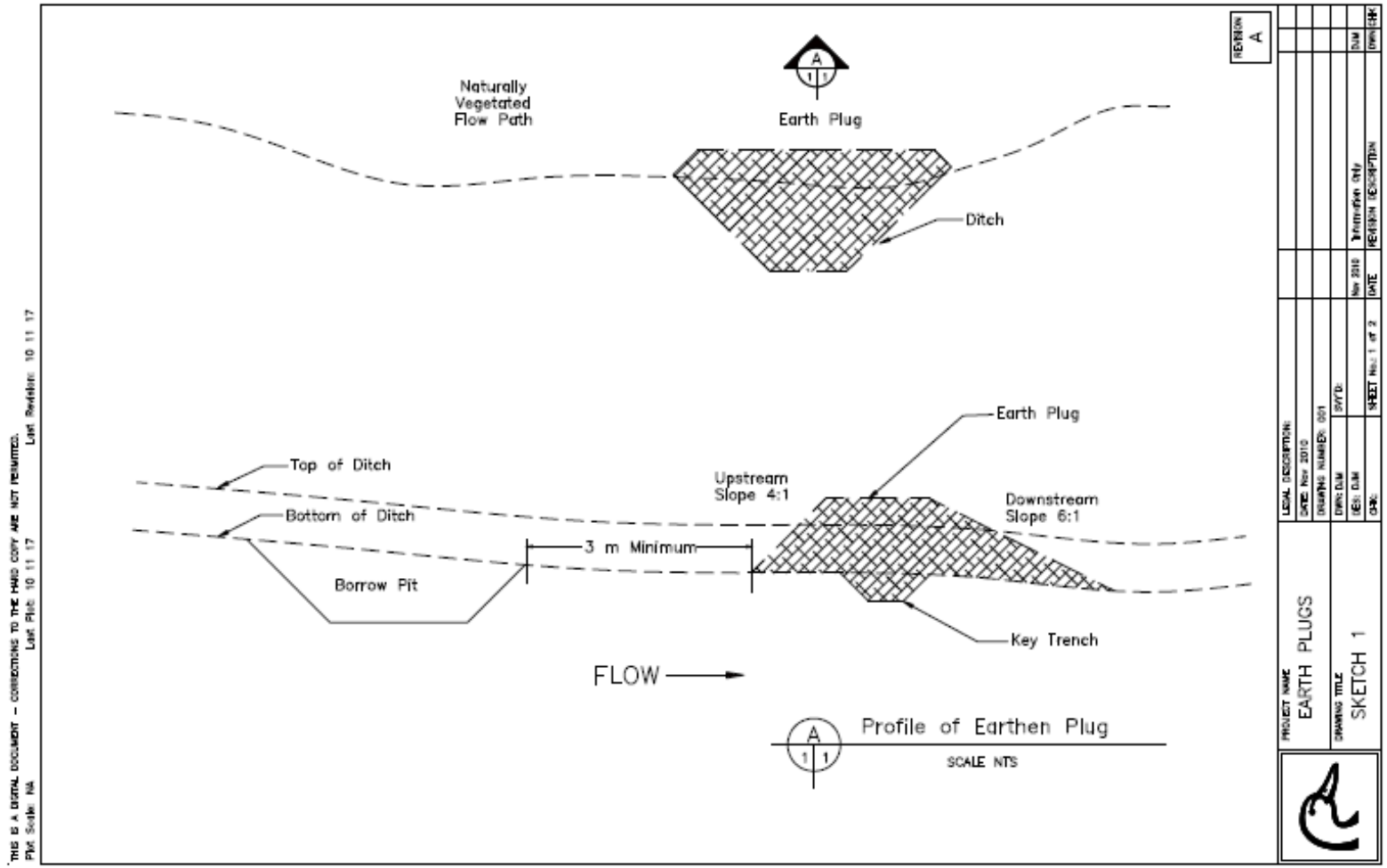
3. Establish a borrow area. The borrow area is usually upstream of the earthen plug within the wetland area. But if the area is too small, the material can be taken from sides of the ditch or from higher ground near the construction.
    The borrow area should be reclaimed in a manner that it is not a liability. Slopes should be graded such that they do not present a hazard to intended uses.
    a. If the borrow area is upstream within the wetland, it should be at least 3.0 meters away from the upstream toe to protect the integrity of the ditch plug slope.
    b. Strip topsoil and stockpile for reclamation of borrow area. This topsoil can also be used to cover the plug.

4. The earthen plug is constructed in a manner which best fits. For most plugs the top width is 3.0 meters and the slopes are 4:1 u/s and 6:1 d/s. The fill material is spread out in lifts of 300mm and compacted by complete track packing by excavation machinery. The fill will meet the elevation of the proposed restoration level.

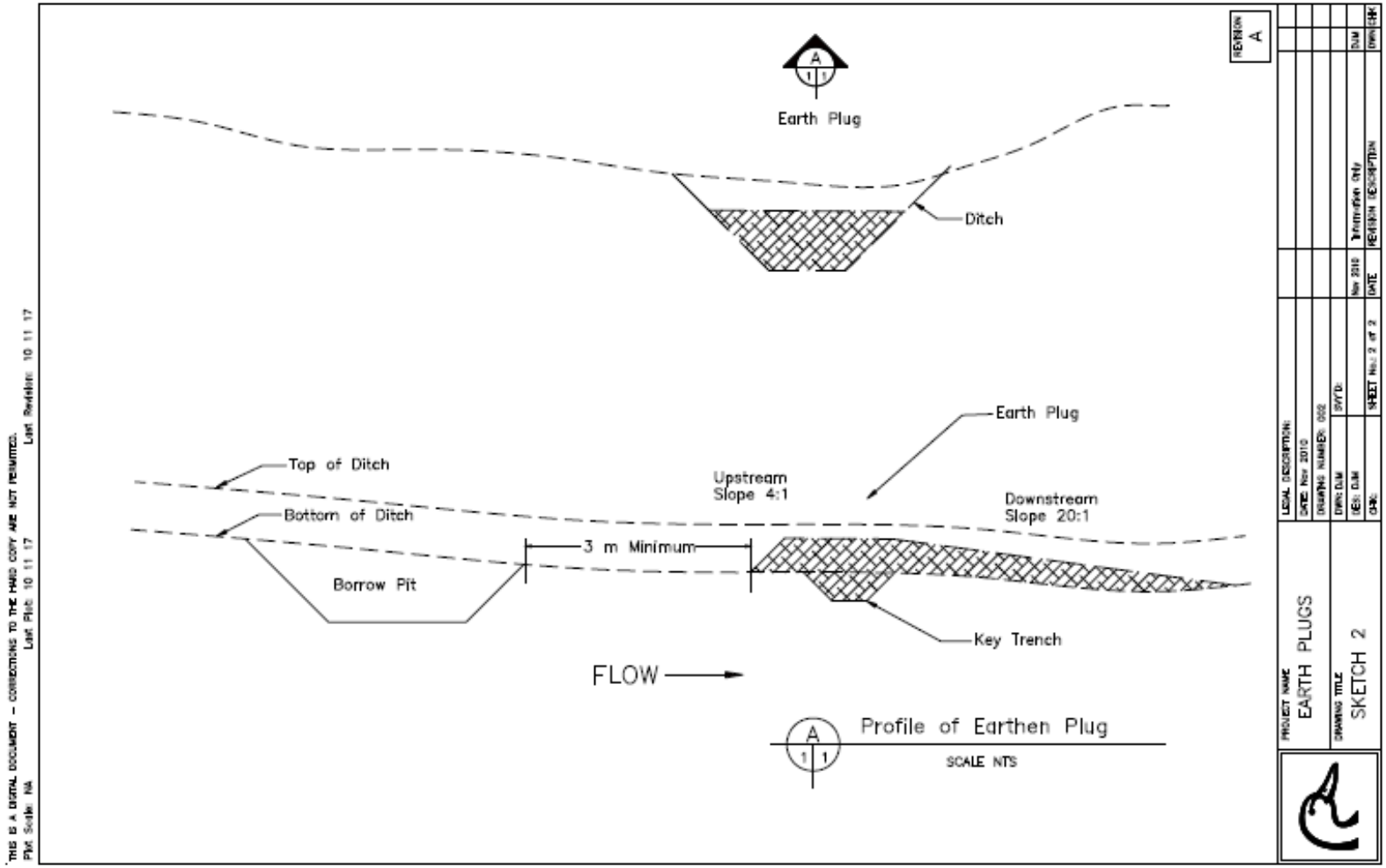
5. The plug and the borrow area will be trimmed, shaped and landscaped. Then seed and harrow.

6. Whenever possible; the ditch plug should be constructed 200 mm higher than the desired level such that flow will be directed to a naturally vegetated flow path. See Sketch 1.

7. Where the flow cannot be redirected the plug should have a downstream slope of 20:1. See Sketch 2.


Naturally
Vegetated
Flow Path
Earth Plug
Ditch
Top of Ditch
Bottom of Ditch
Borrow Pit
3 m Minimum
Upstream
Slope 4:1
Earth Plug
Downstream
Slope 6:1
Key Trench
FLOW
Profile of Earthen Plug
SCALE NTS
PROJECT NAME
EARTH PLUGS
DRAWING TITLE
SKETCH 1

1


Earth Plug
Ditch
Earth Plug
Top of Ditch
Bottom of Ditch
Upstream
Slope 4:1
Downstream
Slope 20:1
3 m Minimum
Borrow Pit
Key Trench
FLOW
Profile of Earthen Plug
SCALE NTS
EARTH PLUGS
SKETCH 2

2
3

Procedures Document - Appendix B Survey Specifications

Provincial standards and specification for vertical survey do not currently exist in Alberta. The following specifications are general guidelines references common terminology used to establish survey benchmarks as stated in the ALBERTA SURVEY CONTROL PRODUCTS MANUAL.

Intent of Survey is to compile GPS observations that comply with the vertical and horizontal measurement standard of a second order benchmark derived from geodetic benchmarks. Compilation of survey observations must achieve decimetre accuracy at a 95% confidence interval for both the vertical and horizontal axis. Survey coordinates are to be collected in the native UTM coordinate system below:

UTM Zone 12

Projection: Transverse Mercator

False Easting: 500000

False Northing: 0

Central Meridian: -111 00 00

Scale Factor: .9996

Latitude of Origin: 0.0000

Linear Unit: Meters

Prime Meridian: Greenwich (0)

Datum: North American 1983 (CSRS)

Vertical Datum: CGVD28

UTM Zone 11

Projection: Transverse Mercator

False Easting: 500000

False Northing: 0

Central Meridian: -117 00 00

Scale Factor: 0.9996

Latitude of Origin: 0.0000

Linear Unit: Meters

Prime Meridian: Greenwich (0)

Datum: North American 1983 (CSRS)

Vertical Datum: CGVD28

Procedures Document - Appendix C Approved Seed Varieties

Variety	Composition
Alberta Native Mix	37% Green Needle 33% Western Wheatgrass 20% Northern Wheatgrass 10% Slender Wheatgrass
Ranchmaster II	50% Meadow Bromegrass 25% Pubescent Wheatgrass 15% Tall Fescue 5% Slender Wheatgrass 5% Alfalfa